SCIENTIFIC REPORTS

OF THE

Agricultural Research Institute, Pusa

(*Including the Report of the Imperial Cotton Specialist*)

1916-17

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1917

Price 9 annas or 10d.

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REPORT OF THE DIRECTOR.

(J. MACKENNA, C.I.E., M.A., I.C.S.)

I. CHARGE AND STAFF.

Charge. I held charge of the office of the Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, and Mr. Wynne Sayer held the post of Assistant to the Agricultural Adviser throughout the year.

Staff. The following changes in staff took place during the year.

Major J. W. Leather, V.D., F.I.C., retired from the Indian Agricultural Service on 12th August, 1916.

Mr. Jatindra Nath Sen, Supernumerary Agricultural Chemist, acted as Imperial Agricultural Chemist up to 28th February, 1917, when he was relieved by the late Mr. J. H. Barnes. Mr. Barnes died of enteric fever on the 2nd June, 1917, after holding the post for three months only. His untimely death is a serious loss to the Institute and to the Indian Agricultural Service. Mr. Sen's services have been placed at the disposal of the Government of the United Provinces from 13th April, 1917, to carry on analytical and special medical work at the Ghazipur Opium Factory.

The appointment of Mr. W. A. Davis as Indigo Research Chemist sanctioned for one year from the 20th

May, 1916, has been extended for a further period of five years. He has also been temporarily placed in charge of the work of the Imperial Agricultural Chemist with effect from the 2nd June, 1917.

Mr. F. M. Howlett, Imperial Pathological Entomologist, was on leave during the year. Mr. T. Bainbrigge Fletcher remained in charge of the Pathological Section in addition to his own duties.

II. Work of the Institute.

Scientific Work. The scientific work of the Institute during the year is indicated in the reports of the various Sections. The special work on indigo, which is in charge of the Indigo Research Chemist, will be dealt with in a separate report.

Training. A number of post-graduate students attended the Institute during the year and short courses were given in sericulture.

In the section of Agricultural Bacteriology an Assistant from the Department of Agriculture, Bengal, continued his training.

A student was deputed by the Patiala State to undergo training in general entomology.

In the Mycological Section an Assistant deputed by the Punjab Department of Agriculture in April, 1917, is still under training.

A private student has been working on indigo since the 25th November, 1916, in the laboratory of the Indigo Research Chemist.

Besides the regular students mentioned above, the following visitors also worked in the laboratories :—

Mr. S. C. Bose, Assistant to the Mycologist, Indian Tea Association, worked for a month in the Mycological Laboratory.

Mr. Ganda Singh Cheema, M.Sc., of the Punjab Government College, Lahore, studied the fungal diseases of cotton and sugarcane crops in the

Mycological Section from the 1st to 27th June, 1917.

Mr. R. K. Parmeshwaram Pillai, Manager, Silk Farm, Trivandrum, deputed by the Travancore State for a course in sericulture, has been under training from the 16th February, 1917.

Six students took the short course in sericulture during the year. Two of these completed their training.

III. Publications.

The Agricultural Journal of India, Scientific Memoirs and Bulletins continued to be issued during the year. The Department published during the year 11 Memoirs and 11 Bulletins; 7 Memoirs, a similar number of Bulletins, and the Proceedings of the Mycological and Entomological Conference (1917) are in the press. A Guide to the Agricultural Section of the Pusa Institute and a booklet on the Importance of Bacterial Action in Indigo Manufacture were also issued during the year. A Bulletin (No. 75) on the Pebrine Disease of Silkworms in India has been extensively distributed free to silkworm rearers and those interested in sericulture in India. It recommends a modification of the Pasteur method which, as used hitherto in India, has failed to eliminate the pebrine disease, one of the principal causes of the decline of the Indian silk industry. It is gratifying to note a steadily increasing demand from the public for the bulletins and as a result it was necessary to reprint during the year the bulletins on Sericulture and on Soil Ventilation and Soil Erosion.

A special number of the Agricultural Journal of India was issued including papers read at the Agricultural Section of the Fourth Indian Science Congress held at Bangalore in January, 1917.

The grant of Rs. 29,000 permanently sanctioned for publications was continued during the year under report. The Publication Section has been reorganized and strengthened.

The form of the Agricultural Journal has been considerably altered and it is hoped that as a result it will gain in popularity.

IV. General Administration.

Administration. Subject to the general control of the Government of India the administration of the Pusa Research Institute is vested in the Director, but the control of the purely scientific work of the Institute (including experimental research work in the field and the publication of scientific papers) is vested in a Council of the Experts with the Director as President. The constitution of the Council was revised during the year and meetings are held at regular intervals.

Buildings and Works. The four clerks' quarters referred to in the last year's report were completed during the year. A set of experimental indigo vats have been constructed. The Government of India have sanctioned the construction of a rest house for Indian visitors and the work will be undertaken as soon as funds are available. The cost of repairs to the many old *kutcha* buildings on the estate is annually increasing and steps are shortly to be taken to demolish the majority as past repair.

With a view to improve the timber of the Pusa estate, the avenues have been carefully thinned and felling of diseased and dead trees and the planting of *sissoo* (*Dalbergia Sissoo*) and teak seedlings is being systematically carried out. Nurseries have also been put down for replacements. The disused land in the building area is being brought under cultivation. The scheme for improvement of the general drainage of Pusa is being proceeded with. Among other minor works and repairs carried out on the estate during the year may be mentioned the construction of two new gates and the improvement of ghat approaches.

The station service vehicles travelled roughly 10,500 miles during the year.

Library. In addition to the numerous bulletins, memoirs, reports, etc., which are received in exchange from

India as well as from different parts of the world, about 325 new volumes were purchased for the library during the year under report. The work of rearranging, classifying and indexing books, periodicals, etc., has been undertaken and is being proceeded with steadily. Index slips of the periodicals were also supplied to the Education Department of the Government of India for the preparation of a General Catalogue of Scientific Literature in the Libraries in India.

Pusa Schools. The total number of pupils attending the Pusa High School on the 31st March, 1917, was 221 against 193 last year. Sixteen candidates have been sent up for the Matriculation Examination of 1917.

The Lower Primary Girls' School was open for about three months, but on the resignation of the school mistress no substitute was appointed, and the school had to remain closed during the latter part of the year.

General Health of the Station. The epidemics of cholera, plague and small-pox, which broke out in the vicinity of Pusa during the months March to June, 1917, and the occurrence of four imported cases of small-pox and two of cholera among the menials coming from the affected villages seriously threatened the health of the station. By cutting off the station from all connection with the affected villages and by keeping the water supply pure, the epidemics were successfully kept out of the station and the general health continued to be good during the year under report. There was, however, one case of enteric fever among the Europeans which unfortunately proved fatal.

A female ward, properly furnished, was added to the Pusa Hospital during the year.

Medical relief was afforded to 11,956 persons of whom 11,659 were treated in the out-patients' department and 297 as indoor patients. One hundred and one cases among the European officers and their families were attended to.

Five deaths occurred in the hospital, but most of the cases were brought into the hospital in rather advanced stages of disease.

V. Accounts.

The total expenditure during the financial year 1916-17 was Rs. 5,18,603, as under :—

	Rs.
Office of the Agricultural Adviser to the Government of India and Director of the Institute	2,18,767
Chemical Section	24,639
Mycological Section	43,221
Entomological Section	41,935
Pathological Entomological Section	10,468
Bacteriological Section	30,571
Botanical Section	45,068
Agricultural Section	69,122
Indigo Research Section	34,812
Total	5,18,603

A sum of Rs. 13,620 was spent from the budget of this Department in 1916-17 in connection with the engagement of Mr. W. Hulme as Sugar Engineer in the United Provinces.

A sum of Rs. 15,000 was paid as a grant-in-aid to the Indian Tea Association.

The principal items of expenditure under the annual grant of Rs. 10,000 placed at the disposal of the Agricultural Adviser to the Government of India for special Agricultural Experiments were as follows :—

	Rs.
Purchase of a threshing machine for the Pusa farm	5,888
Cost of anti-rinderpest serum	754
Grant to the Imperial Cotton Specialist for experimental cotton cultivation	1,500
Pay of a Veterinary Assistant in connection with cattle-breeding and of a Fieldman for mosquito experiments	1,036

The gross receipts during the year from the sale of farm produce, milk, publications of the Department and other

articles amounted to Rs 17,878 as against Rs. 15,340 in the previous year.

VI. Conferences.

In accordance with the proposal of the Government of India to adopt the policy of Sectional Meetings in years in which a full Meeting of the Board of Agriculture is not held a conference of Mycologists and Entomologists was held at Pusa on the 5th February, 1917, and following days. The session was a great success and was attended by representatives of nearly all provinces and the officers of the Indian Tea Association and Mysore State.

VII. Visitors.

No fewer than 136 persons visited the Institute during the year under report. Amongst the visitors were :—

His Honour Sir Edward Gait, Lieutenant-Governor of Bihar and Orissa; the Hon'ble Sir Claude Hill, Member-in-charge of the Department of Revenue and Agriculture, Government of India; Sir Thomas Holland, Sir R. N. Mukherji, the Hon'ble Pandit Madan Mohan Malaviya and other members of the Indian Industrial Commission, Sir George Sutherland, of Messrs. Begg Dunlop & Co., the Hon'ble Mr. W. Maude, Member of the Executive Council, Bihar and Orissa; General Gamble, Inspector-General of Volunteers; the Hon'ble Mr. L. F. Morshead, Commissioner, Tirhoot Division, Mr. J. F. Connolly, Commissioner, Northern India Salt Department; Mr. Puran Singh, Chemical Adviser, Forest Research Institute and College, Dehra Dun; and Thakur Jagannath Baksh Singh, Estate Rahwan, District Rai Bareli (United Provinces).

A party of 25 members of the Bihar Planters' Association paid a two days' visit in February, 1917. Mr. William Bembower, of the Ewing Christian College, Allahabad, with 16 students of his college, visited the Institute in March.

REPORT OF THE IMPERIAL AGRICULTURIST.

(G. S. Henderson, N.D.A., N.D.D.)

I. Charge and Staff.

Charge. I held charge of the post of Imperial Agriculturist during the whole period under review.

Staff. Mr. Deoki Nandan, B.A., M.R.A.C. (Cirencester), was appointed as Assistant to the Imperial Agriculturist on the 1st December, 1916. The First Farm Overseer, Mr. Ikramuddin (with two months' privilege leave), the Second Farm Overseer, Mr. Arjan Singh (with one and a half months' privilege leave), and Mr. Judah Hyam, Veterinary Overseer, remained as last year. Mr. Joseph, the Second Veterinary Overseer, was on military duty in Mesopotamia for four and a half months (from 7th July to 19th December, 1916), assisting in the fly campaign under Mr. Lefroy.

Touring. A tour was made through the North-West Frontier Province and one through the Punjab to see the headquarter station of the Department and the American cotton operations, also the salt lands of the Montgomery District. Also a tour was carried out in Sind when a number of problems connected with the proposed new Indus barrage and irrigation problems were discussed with local officers.

II. Pusa Farm.

A large part of the work of the Imperial Agriculturist consists in the management of the Pusa Farm, in fact the Madras and Bombay press critics of the last annual report stated that the Imperial Agriculturist was simply a farm bailiff. It is possible that, in the early stages of the development of Pusa, the Agricultural Section was overshadowed by the purely scientific sections and much of the energy of the Section had to be expended in preparation and bringing into cultivation of the estate and in other general

work for the common good. It is now possible, however, to carry out the purely agricultural work separately, and it is proposed to work the greater part of the farm on a purely commercial basis and give figures of profit and loss. The demonstration of the working of a large general farm on modern lines with up-to-date machinery is of the utmost importance. Scientific research must be translated into agricultural practice, and agricultural technique for large holdings has seldom due importance attached to it in India. Non-agricultural work such as conservancy, roads and sectional buildings, etc., has been put under the Assistant to the Agricultural Adviser, so the results of the purely agricultural work will not be complicated with extraneous matter.

The results of the farm work are capable of general application to many parts of the non-irrigated tracts of India, but a similar area on one of the large irrigation canals would be necessary for production of results applicable to all India.

Area. The arable area is about 400 acres and grazing about 100 acres. Outside the protective bund, there is 400 acres of rough grazing ground; this is frequently under water for two months or longer.

Rotation. The arable land, with the exception of one field of 40 acres reserved for experimental work and one field for miscellaneous crops for the various Sections, is being cropped with the following rotation :—

	1st year	2nd year	3rd year
Hot weather	Maize for silage and fodder	Maize for corn .	Pulse, green crop
Cold weather	Oats . .	*Arhar* (*Cajanus indicus*)	Oats

One-third of the total area will be manured each year with 10 tons farmyard manure to the acre, and one-third with superphosphate. This rotation will produce both fodder and grain for the large number of live stock at Pusa.

The only exceptions to the ordinary rotation crops are sugarcane and jute; these take the place of the 1st year's and 2nd year's rotations respectively. They are sown early in the season and the moisture conserved in the cold weather by repeated cultivation of the soil; this has to be done for all hot weather crops which are sown before the break of the monsoon in the beginning of June.

Working. After the *rabi* (Winter) crops are cut the land is lightly stirred by steam disc harrow or grubber, then the steam plough is given, the land being well turned to a depth of nine inches. When the first rains break in June the grubber and *hanga* (roller) are put on the land. The *kharif* (Summer) crops are drilled on that at 2-2½ feet apart and kept well inter-cultured by bullock hoes. The silage crops are ready from mid-August and silage making goes on for 4 weeks or so. Brick silos and earth silos sunk in ground are used. A power-driven shredder and elevator cut and make the silage. In October the maize cobs are picked and stored on shelves. Thereafter the cold weather crops are sown after the land has been well worked by steam grubbing and cross grubbing.

The oats are drilled with a 10-row English drill and if possible finished before the middle of November. Harvest begins in March : a large 4′ 6″ Marshall's threshing machine fitted with feeder and straw elevator deals expeditiously with all the grain.

Financial results in past year. The easiest method to get a clear and compact view of the financial results of the farm is to take the produce of the farm as passed over the farm weighbridge and compare with budget cost of running the farm. Rent, rates and taxes are not included, nor interest on capital, the salaries of the higher posts can be written off against the experimental work. Current additions to buildings, dead stock and implements are put against depreciation. The dairy herd is kept as a separate establishment and will be dealt with later.

The produce of the farm is used for :—

(*i*) The up-keep of the dairy herd,

(*ii*) The up-keep of the farm work cattle,

(*iii*) The up-keep of Estate and Botanical Area work cattle and mules.

During the season farm produce was as follows :—

	Maunds standard	@	Total
		Rs. As.	Rs.
Grain			
Oats	3,700	2 8	9,250
Maize	800	2 8	2,000
Peas	700	3 0	2,100
Wheat	300	4 0	1,200
Miscellaneous	300	3 0	900
Total .	5,800	..	15,450
Green Fodder			
Chiefly maize, oats and peas . .	21,800	0 4	5,450
Silage, etc.			
Maize and jowar	14,000	0 6	5,250
Oat straw	10,400	0 4	2,600
Sugarcane	3,900	0 6	1,450
Total .	..	..	30,200

The cost of working the farm was as follows :—

	Rs.
Cultivation	10,700
Clearing and levelling	2,500
Building and machinery	5,200
Workshop	1,100
Implements, etc.	1,200
Petty repairs and supplies	1,800
Establishment	1,600
Total .	24,100

From this has to be deducted the value of one portable engine, one set of cables for tackle and a few other items, total Rs. 5,000.

	Rs.
Cost of working farm	19,100
Value of return	30,200
A profit of	11,100

When the costs of rent, rates and taxes, interest on previous capital expenditure on buildings, equipment and stock, etc., are deducted the balance will still represent a very handsome percentage return on the money spent by Government. The farm, having been well managed in the past, could well afford to be valued at an increased capital value owing to accumulated fertility.

Experimental Work. One field, "Punjabi," has been devoted to experimental work. The area is 40 acres and is divided into 124 plots of a quarter of an acre each and it is enclosed in a wire fence.

The plots have been uniformly cropped under oats for two seasons in order that series of similar plots may be selected for quantitative experimental work. It has been clearly demonstrated at Pusa that field experiment work on untested plots is useless. At present there exists the series of permanent manurial and rotational plots laid down by the Board of Agriculture 8 years ago. Results up to date show the profitableness of manuring with superphosphate combined with green-manuring. Another series is concerned with green manure fermented and applied according to the system evolved by the Imperial Agricultural Bacteriologist. The new experimental work to begin from the present year consists of—

I. *Chilli " Die back " series* for the purpose of finding a method of dealing with *Die back* (wilt) in the chilli crop. Widespread damage has been done by the disease and several methods suggested by the Mycological Department are being tried.

II. *Wheat varieties.* A selection of the most widely-known varieties recently introduced are being carefully tested under practical agricultural conditions.

III. *Pulse varieties.* A number of the most suitable leguminous crops for rotation and for green fodder for cattle are being tested.

IV. *Indigo series.* This consists in manurial and cultural tests on Java and Sumatrana indigo in consultation with the Indigo Research Chemist.

V. *Green manuring.* A new series to replace the old one has been evolved in collaboration with the Imperial Agricultural Bacteriologist.

Buildings, Machinery and Implements. The farm buildings at Pusa need a considerable amount of alteration and addition. Some of the ancient buildings of the old Remount Farm are still in use. The main block of farm buildings is badly congested with old godowns, etc., and new buildings such as Dutch barns, etc., are required. The cattle lines are old horse lines. During the year a beginning has been made in taking down some old buildings; the timber from these has been used for making an implement shed 84′ × 25′ which was urgently required. Some old indigo vats were demolished and the bricks used for roads and putting a *pucca* floor on the cattle lines. The work cattle were brought under one roof, and the milk cattle lines have been improved by removing cross walls and knocking out windows. A wash house fitted with a steam boiler was finished for dealing with the milk vessels.

When money is available modern brick and steel buildings will have to be erected. Most of the produce of the farm such as straw, etc., is at present stored in *kutcha* bamboo buildings which, though cheap in first cost, are decidedly nasty in many ways and are not in keeping with the dignity of the premier agricultural station of India.

Among the main equipment of the farm are the following :—

Steam Plough Tackle. This consists of 2 single cylinder K class Fowler engines and a disc plough, a disc harrow, a grubber, a zig-zag harrow and a roller. The set

B 2

did invaluable work during the year. The cost for the year was—

	Rs.
Labour	1,233
Coal	1,788
Oil	300
Miscellaneous stores, etc., and renewals .	713
TOTAL .	4,034

No allowance is made for interest or depreciation.

	Total acres in season	Cost per acre	Best day's work
		Rs. A. P.	Acres
Ploughing	267	4 6 2	7
Harrowing	498	2 0 9	18
Grubbing	1.080	1 7 4	25
Zig-Zig Harrowing	41	0 14 9	27
Rolling	320	1 5 6	22

The tackle worked 151 days in the year.

Power Machinery. Two portable steam engines are kept employed on various works such as pumping drainage water when the river is in flood, in threshing and in silage making. Chaff cutter, grinding mill and cake breaker and the workshop machinery are driven by electric current from the estate power house.

Silage making and threshing are big items in the year's works. An " Ohio " American shredder is used to cut up the maize and the stuff is carried by elevator either into the *pucca* silos or pits. The *kutcha* pits are more successful than the *pucca* silos. There is less waste and a tight cover can be put on the top with plastered earth.

Threshing is done with a 4′ 6″ Marshall's machine fitted with feeder and elevator. The best day's work done was 427 maunds of oats.

Implements. The chief cultivation implements in use on the farm are the "Punjab plough," price Rs. 27, and the Spring-toothed Harrow made by Wallace Bros. As the fields are large nearly all crops are drilled 2-2½ feet apart with the exception of cold weather cereals. The system of interculture with bullock-drawn hoes is a great saving of labour. The cereals are drilled with a 10-coulter "English drill" and very straight work can be done.

After rain the surface of the soil is kept broken up when required by Wallace's horse hoes, chain and toothed harrows.

A good deal of work has been done in levelling up low places in the fields with a new form of scraper, adapted by the writer. An account of this and a simple wooden plough very useful for rough work has been prepared as a bulletin. Five scrapers with two ploughs working in front of them levelled 17 acres of some very rough rice land at Pusa in 45 days.

III. Farm Cropping.

Maize. Maize is sown for silage and cutting green and also for grain. The local variety is used. Trials with American varieties have not been very successful. Thirty to forty acres are sown in February in land which has been well cultivated in the cold weather to conserve moisture, and this is cut and fed to the cattle, beginning in the middle of May. The main sowing occurs after the rains in June. Trials are being made with *jowar* (*Sorghum vulgare*) sown very thickly as a substitute for maize. When sown like maize the yield is greater but there is waste with woody stalks.

The maize for cobs has *arhar* (*Cajanus indicus*) sown along with it in the drill, this occupies the ground in the cold weather after the maize has been cut out.

In "Chandman" field, 17 acres of maize yielded 323 maunds of silage per acre; cost per acre of growing was nearly Rs. 20 and return Rs. 121.

In " Nepali " field of 22 acres, maize grain came to 10 maunds with 20 maunds of stalk, *arhar* grain came to 14 maunds. Cost of cultivation was Rs. 18 per acre and return Rs. 71.

Oats. Oats are the chief cold weather cereal crop. Bihar oats are probably the best quality grown in India. In the present season the straw was short, especially in fields sown later than the first week in November. It was not possible to get on to some of the fields in good time owing to severe flooding of the farm consequent on the bursting of a large Public Works Department bund.

Two hundred and twenty-four acres of oats were sown, the average out-turn was 17 maunds per acre and $1\frac{1}{4}$ tons of straw. One or two of the flooded fields brought the average down. Fifteen acres in South Punjabi field averaged 29 maunds of grain per acre.

The oat straw is very good fodder and can be fed without chopping.

Pulses. *Arhar* and field peas are both useful rotation cold weather crops. The former is convenient as it has not to be sown at a busy time in October-November, but the yield of grain is less than the peas and the pea straw is useful fodder. Oats and peas cut green gave a yield of over 300 maunds per acre and made excellent fodder for dairy cattle.

For the hot weather a pulse crop for grazing which will keep the ground well covered during the rains is a great desideratum. Fallow ground unless it is high is very difficult to keep clean during the rains. If the water stagnates it is not possible to work it and it becomes a mass of weeds. The pulses being tried for this purpose are cow peas, soy bean, velvet bean, *guar* (*Cyamopsis psoralioides*) and a few others.

Jute and Sugarcane. A quantity of jute is grown for seed by arrangement with the Fibre Expert to the Government of Bengal. It is a useful crop for low ground which is liable to be flooded.

A number of sugarcane varieties are grown on the farm without irrigation. These varieties have mostly been for-

warded for trial by Dr. Barber, Government Sugarcane Expert, Madras. The main crop consists of red and white *Sathi* thick canes. The canes were sold to a factory at 6 annas per maund. In the area sown during the past year cost of cultivation was Rs. 27 per acre and return Rs. 76.

Berseem. A small trial showed that when irrigation was available, this valuable cold weather crop will flourish in Bihar. Around "chars" or depressions when water remains all the year round, its cultivation would be simple. If seed is available in the present year it is proposed to sow some of the "dab" land at Pusa and irrigate from the river. If this be done it would be possible to increase the number of live stock on the farm considerably.

IV. Cattle Breeding.

The breeding herd consists of two separate sections, first, a pure-bred pedigree herd of Montgomery cattle started some 10 years ago, and second, a cross-bred herd formed by putting some of the poorer milking Montgomery cows to imported Ayrshire bulls. There are some excellent strains in the pure-bred herd; the following are some of the best performances during the past season :—

Serial No.	Name of cow	Total yield of milk
		lb.
1	Imani	6,200
2	Jardi	4,978
3	Bhadki	4,906
4	Roomali	4,882
5	Kaveri	4,786

A good deal of weeding out is required but the results on the whole are good. It cannot be said that Montgomery cattle deteriorate when bred in the eastern plains of India. The herd is divided into 5 divisions each of which has a separate bull. In this way it will not be necessary to bring

in outside blood for some time, and eventually it will be possible to move one or more of these divisions to new districts as the nuclei of new pedigree herds which can be worked in connection with Pusa.

The castrated male stock have turned out to be excellent draught bullocks being hardy, 'blocky' animals, standing close to the ground.

The cross-breeding work was started over 3 years ago, so no results are yet available as to the effect of the cross on the milk yield. It is expected that not only the milk yield will be increased but also that the cows will calve more regularly and that it will be possible to wean the calves. It is intended to use cross-bred bulls on the cross-bred cows and not pure Ayrshires. There are at present two imported Ayrshire bulls, Lessnessock Wildfire and Carston Royal Scotch. They want great care to bring them through the rains.

The sole test of inclusion in the herd is the milk pail, points of colour, etc., are not considered.

As a rule the establishment of a pedigree herd is an expensive undertaking, but while the potential capital value of the Pusa herd is very great the actual cost to Government is not large. The herd consists of 125 cows, 10 bulls and 206 young stock. The cost, which would be wiped out many times by the increase of the capital value of the herd, was as follows during the year :—

Returns

	Rs.
Received for sale of milk	6,540
25 young bullocks transferred to work cattle .	1,500
27 head sold at cattle auction . . .	866
13 miscellaneous head, mostly cast . .	425
1 cross-bred bull given to Department of Agriculture, Bihar and Orissa . .	100
TOTAL .	9,431

Cost

	Rs.
Budget head for up-keep of dairy herd including all labour, etc.	3,000
Food due to farm. 3,000 maunds of grain, miscellaneous, at Rs. 2-8-0	7,500
Food due to farm. Green fodder, silage and *bhusa*, 18,000 maunds at 4 annas per maund	4,500
TOTAL .	15,000

That is to say, it cost about Rs. 5,000 last year to carry on the Pusa dairy herd. Considering the huge sums spent by Governments and private agency in other parts of the world on systematic cattle breeding this is not an excessive amount.

The milk is sold direct from the cows and as the customers send their tins to the dairy the milk is not handled at all. It is sold at 10 "Lahori seers" to the rupee or about six pence per gallon.

The feeding of the cattle is done almost entirely with farm produce. At the beginning of the year the long fodder consists of silage and oat *bhusa*, about February green oats and peas are ready for cutting; towards the end of March silage and oat straw are used till mid-May when the early sown maize is ready. The season is carried on with maize and pulses till the end of October when silage is again used.

The grain used is chiefly oats with maize, *arhar*, peas, etc., well ground and fed moistened.

It is proposed to have a public cattle auction sale at least once a year for disposal of all surplus stock. As the sale will be well advertised, people needing cattle will be able to make their arrangements beforehand.

The buildings of the herd are the relics of the old horse-breeding days. They have been made as sanitary as possible but some modern buildings are needed.

V. Training.

The following students received a general practical course in agriculture :—

1. Mr. Piyarey Lal Garg, from United Provinces Agricultural College, from 7th December, 1915, to 30th September, 1916.
2. Mr. Deoki Nandan, from Bharatpur State, from 11th March to 30th November, 1916.

VI. Seed Distribution, Visitors, and Demonstration.

During the year a considerable amount of seed was distributed, among other lots 170 maunds seed oats.

A large number of visitors went round the Section, particulars are mentioned elsewhere. Members of the Bihar Planters' Association visited the farm and a special programme was arranged for the day.

VII. Publications and Correspondence.

One bulletin on "Berseem" and one on "New Implements for India" were written; a Guide book to the Agricultural Section at Pusa and a number of notes for the Agricultural Journal were also written during the year. Evidence was given before the Indian Industrial Commission chiefly on the subject of cotton.

A large number of letters of advice on various agricultural subjects were sent out.

VIII. Programme for 1917-18.

I. Practical treatment of pedigree dairy herd of Indian cattle and pedigree dairy herd of cross Montgomery-Ayrshire cattle.

II. Practical treatment of 1,200 acre mixed farm, with particular attention to profitable modern machinery and the financial results of the work.

The bulk of the produce of the farm is used for the up-keep of the dairy herd. The rotation adopted aims at the up-keep of the fertility of the land along with supply of

concentrated food and long fodder and a constant supply of green fodder throughout the year. Included in the above is the study on a practical scale of—

(*a*) Rotations,
(*b*) Crops for fodder and silage,
(*c*) Implements and machinery,
(*d*) Technique of cultural operations,
(*e*) Types of farm buildings.

III. *Experimental Work at Pusa.* After the preliminary testing of the new experimental area at Pusa, the following will be started and continued along with existing work :—

(*a*) Rotational experiments.
(*b*) Trial of new varieties of existing crops especially leguminous fodder crops, American maizes, foreign oats, and wheat varieties.
(*c*) Manurial experiments, especially seasonal and quantitative tests with phosphates.
(*d*) Rotation and manurial experiments already started.
(*e*) Seasonal and cultural tests with Java and Sumatrana indigo.
(*f*) Fermented green-manuring experiments in collaboration with the Imperial Agricultural Bacteriologist.
(*g*) Trial of sugarcane varieties suitable for growth without irrigation. Some of Dr. Barber's varieties are very promising.

IV. *Demonstrations, exhibitions and cattle sales of* surplus dairy stock, etc., will be held from time to time as occasion offers.

V. *Touring and Advisory.* Visits will be paid to provincial agricultural centres. This should tend towards co-ordination of agricultural work.

VI. *Extension of berseem cultivation.* Seed of this most promising fodder crop will be obtained and distributed in suitable districts.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(W. A. DAVIS, A.C.G.I., B.Sc., F.C.S., IN CHARGE.)

I. ADMINISTRATION AND TOURS.

Charge. The Section was in charge of Mr. J. Sen, M.A., F.C.S., Supernumerary Agricultural Chemist, up to February 28th, 1917, when the late Mr. J. H. Barnes, B.Sc., F.I.C., F.C.S., Imperial Agricultural Chemist, took over charge. Mr. Barnes' untimely death on June 2nd after having served at Pusa only three months will be felt as a great loss not only to the Chemical Section but to Indian agriculture and Indian science. Since 2nd June I have been temporarily in charge of the Section in addition to my duties as Indigo Research Chemist.

Establishment. The services of Mr. J. Sen have been placed at the disposal of the Government of the United Provinces with effect from April 13th to carry out special work at the Ghazipur Opium Factory.

Mr. Bhailal M. Amin, Third Assistant, has been on deputation to the Indigo Research Section from 15th June, 1916. Mr. S. K. Dutt, Eighth Assistant, was transferred to the same Section from 4th January, 1917.

Tours. Mr. Sen went to Cawnpore in September, 1916, to confer with the Deputy Director of Agriculture, Central Circle, United Provinces, on the question of drain-gauge work at Cawnpore and Pusa, and the occurrence of nitrates and alkali salts in soils. A visit was paid to Juhi to witness the reclamation work being carried out there. In December Mr. Sen visited Cuttack to arrange for collection of soils there and in January attended a meeting of the Bihar Planters' Association.

Mr. Barnes in March went to Sabour to examine the diploma candidates in Chemistry and also visited Calcutta to discuss with the Professor of Chemistry in the

Government Presidency College the question of attracting students to Pusa for research work.

In April Mr. Barnes made a tour in the Punjab, visiting Lyallpur and Lahore. At Lyallpur he settled the details of the work to be done on canal seepage and at Lahore attended two conferences, one on the problem of canal seepage and water-logging in the Punjab and the other on the reclamation of saline barren land on the Lower Bari Doab Canal.

II. Meteorology and Drain-gauges.

The work referred to in last year's report has been continued. Waters and crops from the Cawnpore drain-gauges are also being analysed as usual for the United Provinces Department of Agriculture.

III. General analytical work and assistance given to other Sections.

Eighty-six soils have been analysed this year from different sources, 19 samples of manure or materials proposed as manures, 75 samples of feeding stuffs and 34 samples of water. Amongst the materials proposed as manure were spent *mohua* (*Bassia latifolia*) flower and the ash obtained by burning the waste tobacco butts from tobacco factories.

Two samples of *shaftal* (*Trifolium resupinatum*) hay which had been reported as giving rise to cases of poisoning were examined for the Imperial Economic Botanist, no poisonous alkaloid or cyanogenetic glucoside could be detected.

A sample of olive fruit from a Mediterranean variety grown at Taru was analysed and found to contain a high content of oil. A sample of *ajwan* (*Carum copticum*) residue, obtained in the manufacture of thymol, was analysed, the results pointed to the possibility of this residue being used either as a cattle food or manure. Actual trials to utilize this substance are in progress.

In addition to the above work assistance has been rendered to the following Sections :—

(1) *Indigo Research Section.* A large number of soils taken from fields on indigo estates in Bihar, United Provinces and Assam have been analysed in connection with the manurial requirements of these estates (see under *Soils* below) especially as regards the deficiency of available phosphate.

(2) *Bacteriological Section.* Samples of nitrates and nitrate liquors were analysed and analyses made of the gases evolved during fermentation of indigo.

(3) *Entomological Section.* Samples of mulberry leaves, etc., were analysed.

(4) *Agricultural Section.* Analyses were made of standing crops of cane in the various fields, manures, etc.

(5) *Botanical Section.* Samples of feeding stuffs and soils were analysed.

Methods of analysis. Several newly proposed methods of analysis have been tested during the year. The method proposed by Ajon of estimating potassium volumetrically by precipitating as bitartrate and subsequently titrating with alkali was found to give unreliable results, the error being about 2 per cent., the perchlorate method as modified by Davis still remaining the most convenient and most accurate method.

The Bertrand method of estimating sugars, using permanganate has been tested and found to give results often 5 per cent. in error as recently stated by Davis and Daish; its use at Pusa has therefore been discontinued, Brown and Morris' methods as modified by Davis and Daish being introduced.

IV. Soils and Nutritive Value of Crops.

A systematic series of analyses is being made of the soils of the indigo estates in Bihar. The results so far

obtained confirm the view expressed by the Indigo Research Chemist in a recent paper (*Agricultural Journal of India*, Indian Science Congress Number, 1917, p. 77) that the soils of Bihar are extraordinarily deficient in available phosphate, and that their practical depletion of such an essential constituent necessitates systematic manuring with superphosphate if the yield of crops is to be maintained. The effect of this deficiency on the quality and yield of other crops is discussed in the paper referred to and its risk of causing malnutrition and endemic disease in cattle and man. It is also suggested that this deficiency is related to the poor quality of native cattle, the low milk yield from buffaloes in Bihar, and nervous diseases such as *kumri* and defective bone formation in horses in Bengal and Bihar.

The analyses of rices grown in Bihar published by Mr. Sen in *Pusa Bulletin No. 62*, show that they are actually seriously deficient in phosphoric acid as compared with rices grown on soils richer in this constituent.

In connection with the determination of the available phosphate in soils Mr. Sen has carried out a series of experiments which show that the addition of calcium carbonate to a soil giving high values for available phosphate by Dyer's method has a great effect in diminishing the values determined by this method. This is doubtless due to the partial neutralization of the 1 per cent. citric acid used in Dyer's method. The low values obtained for available phosphate in Bihar soils is no doubt also due in part to this cause, as these soils contain abnormally large amounts of calcium carbonate, frequently amounting to 30 or 40 per cent. It must not be concluded, however, that the citric acid method does not remain an extremely useful diagnostic indication of the needs of such soils. In fact it is well known that manurial recommendations based on Dyer's method give the best results in practice in the case of calcareous soils such as those of Rothamsted, where the relative productivity of the soils agrees closely with the determinations of the available constituents by Dyer's

method. The citric acid still gives good diagnostic indications in such cases because the presence of calcium carbonate which lowers the values of available phosphate and potash in the analysis, also interferes with the action of the soil acids in bringing insoluble phosphate and potash into a soluble form suitable to serve as plant food. In Bihar the large increases of crops obtained by phosphate manuring wherever actual large scale trials have been made, agree with the view that there is a serious deficiency of available phosphate in these soils which greatly limits production.

Arrangements have been made for practical trials this year at several indigo factories of the efficacy of manuring with superphosphate.

Some very interesting samples of typical *bangar* and *bhat* soils were sent for investigation by Mr. C. A. Silberrad, B.A., I.C.S., Collector of Gorakhpur. The inferiority of the *bangar* soils was found to be due to the presence of a large amount of sand in it and the absence of a proper amount of lime in the form of carbonate. No harmful *usar* salts were present. *Bhat* soils contain more silt and less sand than *bangars* and are therefore more retentive of moisture.

The Chemical Adviser to the Forest Research Institute visited Pusa in September to study the methods of soil gas analysis in connection with the work undertaken by the Forest Botanist. Apparatus was lent to him in this connection.

V. Feeding Stuffs.

A Bulletin (No. 70) has been prepared summarizing the analyses of the numerous feeding stuffs received in the laboratory of the Imperial Agricultural Chemist. It is hoped that this bulletin will be useful to those maintaining cattle and horses as it gives data for the feeding values of most of the Indian feeding stuffs.

VI. Starch.

The experiments on sweet potatoes (*Ipomœa batatas*) referred to in last year's report have been continued. Five varieties were grown on manured and unmanured soils. The effect of manuring was clearly marked in all the plots and it would appear that the application of manure would pay in the cultivation of sweet potatoes.

Last year's result, that the best time of harvesting the crop is the middle of February, was confirmed this year. The analyses made show that the percentage of starch in the tubers continues to rise till about this time, after which it remains practically constant. There was, however, this year a well-defined increase in the *yield* of tubers after February, probably owing to rains which fell during the first week of February. It is possible that irrigation of the crop during the latter stages of growth would increase the output.

A point of practical importance is that if the manufacture of starch be taken up on an estate, it might be inadvisable to restrict manufacture solely to the sweet potato as the latter would be available only during a short period, namely, about two or three months. In Bihar there is another root crop which is also very suitable for the manufacture of starch and comes on to the market at a different time of year. This is the *suthni* (*Dioscorea fasciculata*) mentioned in last year's report. If both crops are utilized the manufacture of starch would be continuous from November, when the harvest of *suthni* begins, until the end of January or early February when the crop of sweet potato would become available and enable manufacture to be continued until March. In July and August a second crop of sweet potatoes would be obtained and could be utilized.

A sample of starch manufactured from sweet potato (*Ipomœa batatas*) here has been very favourably reported on by Messrs. Reckitt & Sons, Ltd., Hull, who state that at the present time such a product would sell very readily in Great Britain for industrial purposes provided that the

Food Controller would allow it to be used. Messrs. Reckitt state that it is difficult to express a precise opinion as to its selling value, but it seems probable that it would fetch about £20 per ton.

VII. Occurrence of Infertility under Trees.

It is well known that trees often give rise to infertile patches in their neighbourhood. Several causes may co-operate in this and the question has been discussed by Mr. J. N. Sen in some detail, and a collection of data has been obtained in Pusa which throw light on the question. It is shown that several trees, especially the bamboo and tamarind, bring about a concentration of soluble salts in the upper layers of the soil in their neighbourhood, probably largely owing to transpiration. An examination of *good* and *bad* soils in the neighbourhood of trees growing in different areas showed that the good soils generally contained less than 0·3 per cent. of soluble salts but that bad soils often contained more than 0·5 per cent. The nature of the soluble salts, however, greatly modifies their effect in limiting fertility.

VIII. Tobacco and Transpiration Ratio Experiments.

Pot and field experiments were started last cold weather to ascertain the effect of different manures on the yield, quality and nicotine content of tobacco plants and to ascertain the effect of aeration on these. The work is still in progress.

The experiments referred to in last year's report on the relation between transpiration by a plant and the assimilation of plant material have been continued but not yet completed.

IX. Programme of Work.

Major subjects.

1. Continuation of the investigations into the amount and nature of drainage water from fallow land and land bearing crops.

2. Continuation of the work on tobacco and starch up to the point necessary to complete the present investigation.

3. Experiments on the *bara* soils of the Punjab in connection with reclamation schemes. This work had been proposed by the late Mr. J. H. Barnes and it is hoped can be continued in collaboration with Mr. Wilsdon, Agricultural Chemist to the Punjab Government.

4. Continuation of a survey of indigo soils.

Minor subjects.

1. Checking analytical methods at present used at Pusa in agricultural analysis.

X. List of Publications.

(1) W. A. Davis . The Phosphate Depletion of the Soils of Bihar, and its Contingent Risks of Malnutrition and Endemic Disease: A Warning. *Agri. Jour. of India*, Vol. XII, Part II.

(2) W. A. Davis . The Phosphate Depletion of the Soils of Bihar: Its Effect on the Quality and Yield of Crops and the Contingent Risks of Malnutrition and Endemic Disease in Cattle and Man. *Agri. Jour. of India*, Indian Science Congress Number, 1917.

(3) J. N. Sen . . The Influence of the presence of Calcium Carbonate on the Determination of Available Phosphoric Acid in Soils by Dyer's Method. *Agri. Jour. of India*, Vol. XII, Part II.

(4) J. N. Sen . . Composition of some Indian Feeding Stuffs. *Bulletin 70, Agricultural Research Institute, Pusa.*

(5) J. N. Sen . . Some Observations on the Occurrence of Infertility under Trees. *Agri. Jour. of India*, Vol. XII, Part III.

(6) J. N. Sen . . Report on Agricultural Chemistry for Board of Scientific Advice.

REPORT OF THE IMPERIAL ECONOMIC BOTANISTS.

(A. Howard, C.I.E., and Gabrielle L. C. Howard, M.A.).

I. Introduction.

The Imperial Economic Botanist held charge of the section during the year.

The work of the staff continues to be satisfactory. During our absence from Pusa, the current work of the section was carried out by the Second Assistant, Maulvi Abdur Rahman Khan, except for two months during the monsoon of 1916 when he was on privilege leave. During this period, his place was taken by the Third Assistant, Choudhry Ram Dhan Singh. Both these assistants carried out successfully a large amount of responsible work. The Fourth Assistant, Babu Kashi Ram, has made himself very useful in connection with the experiments on the drying of vegetables.

Mr. Jatindra Nath Sen, Officiating Imperial Agricultural Chemist, carried out a good many analyses for the section which have proved of considerable use in our investigations.

II. Investigations at Pusa.

1. Wheat.

Pusa 12. The popularity of Pusa 12 continues to increase and the demand for seed is still much greater than the supply. At an early period of the last harvest, a large quantity of the seed of this variety, grown on the indigo estates in Bihar, was taken up by Mr. Burt for general distribution in the Central Circle of the United Provinces. The remainder was secured by the Director of Agriculture for use in South Bihar.

The demand for botanically pure selected seed of Pusa 12 for the purpose of re-stocking existing seed farms and for opening new centres was again very great but it was possible to deal with only a portion of the indents received.

In the previous report, the replacement of the country wheats by Pusa 12 in the United Provinces was described in detail and some reference was made to the various means employed. This work was again vigorously prosecuted during the year particularly in the Central Circle and in Oudh where large compact blocks of Pusa 12 are now to be seen at harvest time. On the seed farms of the Amethi Raj, an area of fifty-four acres yielded at the rate of 24 maunds to the acre. Now that the wheat profits have been devoted to the extension of seed farms, future progress in the United Provinces is likely to be still more rapid.

On the Chenab Colony of the Punjab, the advantage of growing Pusa 12 is beginning to be realized. At Gungapur, one of the large private estates in the Colony managed by Rai Sewak Ram Sahib, Pusa 12 is now the main crop and at harvest time this year this estate alone produced over 15,000 maunds of this variety. Comparative trials of Pusa 12 and Punjab 11 on this estate last year gave the following results :—

	m.	s.	
Pusa 12	19	32	per acre
Punjab 11	16	18	„ „

The plots in each case were 3·88 acres in area. There is one drawback, however, to the spread of this variety on the canal colonies, namely, the fact that at present the wheat crop is greatly overwatered. Pusa 12 is a deep-rooted wheat which does not like too much water. At Gungapur this year, this wheat gave over 12 maunds to the acre on the preliminary irrigation only. When the cultivators in this region practise water-saving methods, it is more than probable that the potential superiority of this wheat will become more evident.

Pusa 12 is now being systematically distributed by the Agricultural Department in South Bihar where its superiority over the local wheat has been established as the result of numerous trials. A large amount of seed was supplied this year to the Director of Agriculture from the Dholi estate.

One set-back to the spread of Pusa 12 has to be recorded, namely, the damage done by the late rains when the wheat was on the threshing floor. This was most severe in the Western Districts of the United Provinces. In Bihar and Oudh, threshing at the seed farms was fortunately completed before the rains came.

Pusa 4. Where a rapidly maturing wheat is required, Pusa 4 is in great demand. In Bundelkhand, Mr. Burt has been distributing this wheat for some years and after last harvest it came into the market for the first time in bulk. The available supply was bought up at a substantial premium by Messrs. Shaw Wallace & Co., for use in their mills at Calcutta.

In the Central India States, a beginning has been made in the trial of Pusa 4. Very good crops were obtained, particularly under irrigation, and a larger quantity of seed is being given out for sowing next October.

The quality of Pusa wheat. In connection with some milling and baking trials carried out by Mr. Humphries at Weybridge, the opportunity was taken of re-testing the original stock of Pusa 4, Pusa 6, and Pusa 12 after an interval of nine generations. No change in the milling and baking qualities could be detected. All these three wheats yielded excellent bread, the loaves from Pusa 6 being perhaps the best. This is fortunate as two very promising series of crosses on this variety have now been fixed and are ready for field trials.

Wheat-breeding. While the Pusa wheats now being grown on large areas in India are markedly superior to the country wheats in yield and quality, nevertheless they are by no means the last word in plant-breeding in this crop.

Four series of crosses are now under investigation, the two most promising of which have been derived from Pusa 6. In these, an effort has been made to combine strong rooting and standing power with rust-resistance, yield and high grain quality. Some of these wheats were tried at Gurdaspur on a field scale and very high yields were obtained. Unfortunately these trials were to some extent interfered with by exceedingly heavy rain at harvest time but sufficient work had been done before the deluge to indicate the possibilities of the new types. During the coming year, further trials of these new types have been arranged for in Central India while the work at Gurdaspur will be extended.

The effect of soil temperature on development. For some years, the cause of the dying-off of the young wheat crop soon after sowing in Bihar has been under investigation at Pusa and during the last three seasons a simple remedy has been tried with success. Experience shows that the dying-off of the young wheat crop is particularly widespread in Bihar and Oudh in years when the total monsoon rainfall is large, when the rains cease early and when the sowing rains (*hathia*) fail. In such seasons, the soil is charged with large quantities of warm water and cooling is slow on account of the mass of water involved and the practice of keeping the soil closed down to prevent too much evaporation. Such soil conditions occurred in Bihar in 1914 and again in 1915 and whenever they do, it is interesting to note that the *ryots* always sow too early and often lose their wheat entirely, particularly on the heavier lands which hold the most moisture and presumably cool down more slowly than the drier, higher-lying fields. The remedy for this trouble in such seasons in North Bihar is to postpone sowing till the end of October and to cool the soil by evaporation by allowing the furrows to remain open to the sun and air for three or four days according to the amount of moisture present. When this is done, there is much less trouble on account of a hot seed-bed and white ants do little or no damage. For two seasons, this remedy has been

adopted on the Dholi estate on the large scale, and has proved of the greatest use. Previously, this estate often lost large areas of wheat from a hot seed-bed.

2. Tobacco.

The increasing popularity of Type 28 for cigarettes in many of the tobacco-producing districts of India and Burma mentioned in the last report has become still more marked during the last twelve months. Not only for cigarette manufacture but also for general use, the cultivation of this type continues to spread. The indents for seed are increasing both in numbers and in the total weight required. From all sides favourable results are reported. The principal agent of distribution is the branch of the Peninsular Tobacco Company at Dalsing Serai in North Bihar where the seed given out to *ryots* in the present year was much greater than in 1916. Numerous indents from South Bihar, the United Provinces, Punjab, Bengal and Burma were also received. To meet the increasing demand for seed, it was necessary to postpone the plant-breeding work in this crop last year and to devote the area set aside for this investigation to the growth of seed for distribution.

3. Fibres.

Considerable progress has to be reported on the Mendelian work in connection with the varieties of Roselle (*Hibiscus Sabdariffa*). The gametic constitution of the four varieties described in the Botanical Series of the *Memoirs of the Department of Agriculture in India*, (Vol. IV, No. 2) has proved to be exceedingly complex and a very large number of unit species has now been isolated in pure culture. The unravelling of the various problems involved in this work will shortly reach a stage when it will be possible to commit the results to paper.

In the case of *patwa* (*Hibiscus cannabinus*), an improved variety of which was brought out some years ago under the designation of Type 3, further promising reports have been received from various parts of India. These reports, how-

ever, were almost invariably accompanied by requests for larger quantities of seed true to type. A large indent came from the Government of Java. Only a fraction of the seed asked for could, however, be supplied in spite of a fairly satisfactory yield last harvest. An effort is being made this year to increase the area under Type 3 so as to meet the more important indents which have had to be postponed.

4. Indigo.

The results so far obtained on the improvement of indigo in Bihar and the work in progress on this crop were summed up in the *Third Report on the Improvement of Indigo in Bihar* which was published as Bulletin No. 67. Since this appeared, some further results were described in a paper on *the economic significance of the root-development of agricultural crops* read at the Indian Science Congress at Bangalore last January.

One of the problems relating to the indigo industry, namely, the seed supply, has continued to receive attention at Pusa. The conditions found to be necessary for seed production under Bihar conditions are the following : (1) the type of plant selected must be a rapidly-growing, early-flowering, bushy form with a large proportion of the lateral roots comparatively near the surface, (2) the seed must be sown in early August on high-lying, well-drained land in good condition, (3) the surface soil must be constantly cultivated during the monsoon phase to promote abundant aeration of the roots of the young crop, (4) after the *hathia*, the crop must be deeply cultivated and till seed formation is complete, any rain crusts formed must be broken up, (5) the plants must be well spaced from the beginning so that they can branch freely and the flowers formed can be visited by bees, (6) the cultivation should be so conducted that flowering takes place between the middle of October and the end of November by which date the plants should be fully loaded with pods. Proceeding on these principles, a seed crop of over sixteen maunds to the acre was obtained last season, the highest yield so far obtained at Pusa.

The effect of improved soil aeration on the production of seed in Java indigo (which has been noticed at Pusa) is becoming evident elsewhere. At Dehra Dun, where our selected indigos are being grown for seed on drained land, the favourable effect of the drains on the growth of the plant is very marked. At Ranchi, Mr. G. Milne, I.C.S., Director of Agriculture, Bihar and Orissa, reported an interesting case where a field of seed indigo failed except where large quantities of broken bricks had been added to the soil.

A study of the botanical constitution of the Java crop yielded some interesting information particularly with regard to the root-system of the various types. All the types examined were found to possess the deep anchoring root. In addition, a general correspondence between the modes of branching of the root and of the stem was observed. In the bush types, which branch at right angles to the axis, the lateral roots are also given off at right angles to the main tap root. In the vertical types, whose branches arise at an acute angle from the stem, the lateral roots arise at an angle very similar to that of the branches.

The following types of root development have up to the present been found :—

(1) *Early bush types* in which nearly all the lateral roots are at right angles and are concentrated near the surface.

(2) *Early types with a vertical habit* in which nearly all the lateral roots are concentrated near the surface but all point downwards.

(3) *Late bushy forms* in which there is a development of lateral roots from the surface to a great distance down the main root.

(4) *Late types of vertical habit* with lateral roots pointing downwards arising at regular intervals down the long main root.

(5) *Types with hardly any side branches* but a deep tap root. These types scarcely branch at all either above or below ground.

It will be obvious that if aeration is of any importance, the type which will thrive best in the monsoon in Bihar is type 1 and that type 2 will be the next best. Even if the lower portion of the root-system in these types is asphyxiated, the upper portion would be sufficient to carry on growth. Plants belonging to types 3 and 4 would lose a large portion of their root-system and even if they could struggle on would not thrive. Plants of the fifth type would be killed out. Experience shows that this is the case. Rapidly-growing, bushy indigos with most of the root-system near the surface, have successfully withstood the monsoon, while deep-rooting types belonging to classes 3, 4 and 5 have died out.

5. Gram.

After the heavy monsoon of 1916, the land at sowing time at Pusa was much too wet for gram cultivation. As was expected, the growth was very luxuriant but the yield of seed was far below the average. It is only occasionally that the highest and driest plots at Pusa are in the right condition for testing gram varieties. This circumstance has greatly hindered the work on this crop. A large number of varieties have been isolated, some of which are very promising, but it is exceedingly difficult to carry out the final trials for yield and to eliminate the less efficient types. As this work has now been hung up for several years, it is hoped to make suitable arrangements for the trials in the United Provinces.

6. Oil-seeds.

It appears from the literature that up to the present no arrangements have been made on a practical scale to have the seed of safflower (*Carthamus tinctorius*) examined with a view to its utilization in the arts. The seed is rich in oil which at present is said to be largely used for adulterating *ghi*. As it is probable that the oil may be of use in water-proofing cloth, a consignment of about a ton has been sent to England for full tests under factory conditions. If the seeds prove of value in Great Britain, it will not be a diffi-

cult matter to work up an export trade and to make use of some of the improved types of this crop isolated at Pusa.

Considerable progress was made during the year in the preliminary classification of the various types of Indian linseed so as to furnish suitable material for the further study of this crop. It is hoped to complete this introductory work during the next *rabi* season. A large number of forms have been isolated, and as was expected, the range in root development is very great.

7. Soil-aeration.

During the year under review, a large body of evidence in support of our published views on soil-aeration has accumulated. Confirmatory results from the cultural and anatomical standpoints have been published in Great Britain by one of Professor Potter's students. In India, the dependence of quality on soil-aeration has been confirmed by Mr. Clouston's experiments on cotton, sugarcane, and ground-nuts at Chandkhuri near Raipur on the *bhata* soils of the Central Provinces. At Pusa, a study of the root-systems of the types of linseed, Roselle, *patwa*, wheat and Java indigo has shown that all the varieties which really do well on the Bihar alluvium are surface-rooted kinds, while on the other hand the forms which do not thrive are deep-rooted. The facts so far brought to light indicate the all importance of soil-aeration during the monsoon phase and also confirm our ideas on the general importance of this factor. The addition of one inch of potsherds (*thikra*) to the heavy soils of the Botanical area has led to a considerable increase in the yield of grain per acre—in the case of oats the increment was 366 lb. per acre, in wheat 269 lb. per acre.

III. The Development of the Agriculture of Baluchistan.

Thanks to the increased facilities provided by the Baluchistan Administration and the effective co-operation

of the Army, the agricultural work carried out at the Fruit Experiment Station at Quetta has been extended very considerably during the year. The district work among the cultivators has necessitated the appointment of a Travelling Instructor in Agriculture while the fodder experiments in progress with the Army have involved extra expenditure on presses and seed. The cost of the experiments on vegetable drying has been met by a grant from Army Headquarters, Simla, while the fodder trials have been financed from an advance of five thousand rupees from the Assistant Director of Supplies and Transport, Fourth (Quetta) Division. The supply of fruit boxes to the public has been made possible by means of temporary loans from the Treasury.

1. The saving of irrigation water.

The principles underlying water-saving were referred to in detail in the last Annual Report as well as the result of a trial of the new system on the fields of a *zamindar*. During the past year, the demonstration work has been extended considerably near Quetta and trials have also been carried out by the Political Agent at Pishin and by the Irrigation Officer at Khushdil Khan. In spite of the fact that the winter rains last season were less than half the average, none of the demonstration crops failed and in all cases the wheat reached maturity and good yields were obtained, in some cases over 20 maunds to the acre. The success of the new methods, when carried out under cultivators' conditions, is now assured and their general adoption is only a question of time. In connection with these trials it is satisfactory to note that the people are taking to the lever harrows for crust-breaking and are favourably impressed by the rate at which irrigated land can be dealt with by the combined use of the five tine spring-tooth cultivator and the levelling beam. For the operations connected with tilth production and water saving prior to sowing, the spring-tooth cultivator is essential and its use in areas like the Pishin Valley will multiply the available cattle power by a

factor lying between 2 and 3. The Irrigation Department is co-operating in the work of bringing the new methods to the notice of the people and in teaching them the proper use of the lever-harrow and spring-tooth cultivator.

In addition to the discovery of the best means of utilizing the preliminary irrigation, other aspects of water saving have been investigated at Quetta. The results were published in a bulletin entitled *The irrigation of alluvial soils* which was afterwards reprinted in the *Agricultural Journal of India.* In this paper, the present methods of irrigation in Baluchistan and the plains of India were considered as well as the conditions underlying any successful modification of existing practices. What is wanted is a system which fulfills the following conditions :—

(1) The amount of water used must be as small as possible and the losses in the channels must be reduced to the lowest point.

(2) The method of distribution must be simple and inexpensive and must be designed to admit of the use of labour-saving devices such as harrows and reapers.

(3) The system must admit of *surface-drainage for each field* during the rains, and it must be such as to prevent the production of alkali salts.

(4) The method must be such as to assist the process of green-manuring in those areas where this is possible.

A method of irrigation based on these principles has been worked out at Quetta which appears to be a considerable improvement on present practices. The chief points in the method are the better grading of the land to be irrigated, the use of long compartments watered from one end, the provision of surface drainage where necessary, the improvement of the field channels and the control of the water by means of the canvas dam. This paper has received a good deal of favourable notice in the press and applications for a considerable number of copies have been received.

The general applicability to the plains of India of the Quetta results on water saving was demonstrated during the past wheat season. A study of the wheat crop on the Chenab Colony and the marked contrast between the manner of ripening of the same variety, grown under canal irrigation at Lyallpur and under natural moisture elsewhere, convinced us that it would be quite safe to predict that a large proportion of the canal water is wasted in the North-West. Accordingly, a memorandum to this effect was drawn up and submitted to the Director of Agriculture of the Punjab which contained detailed directions as to the actual procedure to be followed. During the past season, the new method was tried at three centres in the Punjab—Gungapur, Haripur and Sargodha. All facilities for the experiments at Gungapur and Haripur were kindly given by Rai Sewak Ram Sahib. The Sargodha trials were carried out by Maulvi Fateh-ud-Din, Deputy Director of Agriculture. In all cases, the trials were successful and quite fair crops were ripened on the preliminary irrigation (*rawani*) only without any assistance from the winter rainfall. With one more irrigation, good crops were obtained. The details are given in Table I below from which it will be evident that after the second irrigation water ceased to be a limiting factor in growth.

TABLE I.

Results of water-saving experiments on wheat (Pusa 12) at Gungapur, Haripur and Sargodha in 1916-17.

Station	No. of irrigations including the preliminary watering	Yield per acre		Average yield per acre	
		Grain	*Bhusa*	Grain	*Bhusa*
		m. s.	m. s.	m. s.	m. s.
Gungapur . .	One	12 19½	20 10		
Haripur . .	"	8 31	19 14	9 34	21 17
Sargodha . .	"	8 12½	25 27½		

Results of water-saving experiments on wheat (Pusa 12) at Gungapur, Haripur and Sargodha in 1916-17—contd.

Station	No. of irrigations including the preliminary watering	Yield per acre				Average yield per acre			
		Grain		*Bhusa*		Grain		*Bhusa*	
		m.	s.	m.	s.	m.	s.	m.	s.
Gungapur . .	Two	18	0	25	8	16	11	25	5
Haripur . .	,,	15	21	23	16				
Sargodha . .	,,	15	12½	26	32½				
Gungapur . .	Three	14	25	18	0	15	11	22	2
Haripur . .	,,	16	8	26	4				

Similar results were obtained during the last cold weather at Mirpurkhas in Sind by Mr. T. F. Main, Deputy Director of Agriculture in Sind.

In the ordinary way, the Punjabi cultivator irrigates four times for wheat—once for the preliminary preparation and three times afterwards. So inexpert are his methods that the first watering does little more than germinate the crop and carry it through the seedling stage. At an early period of development, a second watering is necessary often followed by two more—one after the New Year and the last to complete the ripening process. When water is short, only two waterings are given after sowing. At Gungapur, a yield of over twelve maunds to the acre was obtained on the *rawani* only, a result which one of us was informed in 1916 was quite impossible. Very good wheat crops can be obtained on the Canal Colonies with two irrigations and it is possible to save one-third to half the water now used. Similar results are possible on the rest of the alluvium and to a considerable extent also on the soils of the Peninsula. Translated into money, this result runs into large figures. The annual revenue derived from Government irrigation works in India is about £5,000,000 sterling.

In addition, there are numerous private irrigation works as well as a large number in the Native States. Taking the Indian Empire as a whole, there can be no question that the water wasted every year would, if used to the best advantage, bring in a very large direct revenue to the State. This of course is only one aspect of the case. Increased production means more seed to be moved by rail, more dues at the ports and a great stimulation of trade following the increased spending power of the people. A good deal of work will be necessary before India can reap the full results of these experiments. Proposals for the further development of the work have been submitted to the Government of India.

2. The improvement of fodder production.

In the last report, a detailed account was given of the preliminary trials with baled *shaftal* (*Trifolium resupinatum*) which had been carried out by various units of the Fourth Division. During the year, these trials were considerably extended and 645 maunds of *shaftal* hay were supplied for trials to various units, the details relating to the tests being supervised by Brigadier-General Cook, R.G.A. The results of these large scale experiments were exceedingly satisfactory. The Revenue Commissioner has arranged for a hundred acres of *shaftal* to be sown near Harnai which will be dried and baled next year for the Quetta Garrison. The introduction of this fodder into the Harnai Valley is expected to provide a useful rotation crop and to increase the yield of the cereals now almost exclusively grown in this tract. In other respects, Harnai is a very suitable place for this work. Water is abundant and it is situated at the rail-head of the Loralai Fort Sandeman road. The military advantage obtained by the use of such fodders is a reduction of about thirty per cent. in the total weight of forage carried on active service.

With a wider experience of the cultivation of leguminous fodder crops under Quetta conditions, the dependence of the yield on soil-aeration has become more and more

marked. In the case of lucerne, the withholding of irrigation during the resting period markedly increases the yield the following year. The rest from surface-flooding during the winter enables the soil to regain its tilth in a remarkable way. The restoration of the tilth is shown by the level growth all over the area and the small edge effects. Plots which have been irrigated during the winter, on the other hand, always show pronounced edge effects and only grow well next to the earth bunds separating the irrigation compartments. In the case of *shaftal*, soil-aeration has been found to be exceedingly important at sowing time and the crop establishes itself far more readily on a recently cultivated surface than under a crop of maize or *juar*, the soil of which has been consolidated by several waterings. The presence of aerating agents in the soil also increases the life of the crop and the total yield of fodder and seed. A good deal of work is in progress on these matters which promises interesting results.

During the last five years, considerable quantities of green fodder, mostly *shaftal*, have been sold to the Military Dairy at Quetta. *Shaftal* is much appreciated at this Dairy on account of its value in milk production. The Manager of the Dairy, Mr. J. H. Riddick, referred to this matter in his report for 1916 as follows :—

> "Mr. Albert Howard, M.A., C.I.E., Imperial Economic Botanist, has assisted the Dairy by disposing of the whole of the green fodder grown at the Fruit Experiment Station to the Dairy authorities, which resulted in a most satisfactory increase in the milk yield of the animals at the Quetta Dairy. His advice on improved irrigation methods and with regard to other agricultural improvements has been of much assistance to the management."

3. The sun-drying of vegetables.

One of the difficulties encountered in connection with the supplies needed by the Army of Mesopotamia has been the provision of vegetables for the troops. In the fresh condition, transport is difficult and expensive and involves the use of cold storage at sea and at the base. In 1916, the Bota-

nical Section of the Pusa Institute was asked by the Quarter Master General to suggest means of overcoming this difficulty. The suggestion was made that the vegetables should be dried in the sun at suitable places on the Western Frontier before despatch to Mesopotamia. We undertook to work out the details of the process at Quetta, where the air is exceedingly dry, and to assist the Army in the work in the event of the method being taken up on the large scale. After an interview with General Vaughan, Director of Supplies and Transport, at Delhi in March, this was agreed to and a grant to cover the cost of the experiments was placed at our disposal by the Army. While arrangements for the work were under discussion, Baghdad was taken and the Army occupied a fertile region from which supplies of fresh vegetables could be obtained. The operations on the large scale, which had been decided upon at Quetta, were accordingly revised. It was decided to continue the work but on a smaller scale and to dry sufficient produce for the Aden garrison for a year. A portion of the vegetables necessary were grown at Quetta by the Army, the remainder at Dhadar and Mustung by the Kalat State.

The first step in the process was the working out of a suitable method of drying vegetables in the sun. This was taken in hand early in the season in April and May. The work was practically completed by the middle of June and full details were supplied to the Army before the vegetables at Quetta and Mustung were ready. A large number of vegetables, both European and Indian, were successfully dried, the cooked product in nearly every case being almost indistinguishable from fresh.

As dried vegetables are very bulky, it was necessary to find some cheap method of storing and transporting the produce. This was accomplished by steaming and pressing into bricks, one pound in weight and of such a size that they could be packed into kerosine tins which could then be soldered. For this purpose, a suitable press had to be designed. The result of this portion of the investigation was a great success and reduced the space taken up by the

product to about one-seventh. Packed in this manner, it is possible to compress the weekly supply of vegetables necessary for a battalion on active service into twelve kerosine tins which can be transported by two mules. At the time of writing, the process is in full operation in the Quetta Cantonments where a large drying ground has been arranged by the Army.

The vegetable drying experiments have aroused a great deal of interest among the *zamindars*, a large number of whom have visited the drying ground. A detailed report of the process is now in the press and it is proposed to have this translated into Urdu for local circulation. There is every prospect that the work will lead to the foundation of a new local industry.

4. Fruit-packing.

The sale of improved fruit boxes to the public during the year exceeded all expectations. It was stated in the last report that a large supply had been procured for 1916 more than sufficient to meet any demand that was likely to arise. Early in the season, however, the sales increased so rapidly that it was difficult for the staff available to place the boxes on the market fast enough. The Indian traders bought up all the crates and punnets before the season was half over and only a few peach boxes were carried over for 1917. During the season, 4,398 boxes and 366 punnets were sold, the proceeds amounting to Rs. 5,028. Had the stock been larger, boxes to the value of at least Rs. 7,500 would have been sold. The Indian dealers have now realized the value of the two-pound punnet, suitably arranged in crates, for the transport of grapes. By means of these crates, Baluchistan grapes reach distant cities of India like Madras, Bombay and Calcutta without damage. In consequence, the demand from India has increased and is likely to increase still further. The only thing needed for stimulating the grape trade was a suitable method of packing for transport and this has now been provided. The valleys of Baluchistan are eminently suitable for the cultivation of grapes. The

crop escapes the early frosts and little irrigation water is needed as the plants are grown in deep trenches protected from the drying winds. Very rarely is the crop damaged by rain during the ripening period. As regards the market, this is provided by the teeming population of India, a large proportion of whom are vegetarians who are willing to pay good prices for this fruit.

Baluchistan labours under one disadvantage as a fruit-producing area. This is the absence of a supply of cheap wood for the fruit boxes. The wood has either to be brought by sea from Norway or else hauled across the Punjab from the valleys of the Himalayas. The cost of freight on the box boards will always militate against the use of the light non-returnable package which is only used once. A method of getting over the difficulty is to use stronger crates and to arrange for their return to Quetta so that they can be used over and over again. If a crate would last for 20 to 30 double journeys to and from Quetta, the cost of the package per trip would not be very great. It might then easily pay the more substantial merchants to put a certain amount of their capital into well made crates. A suitable returnable crate has been designed and has been on the market for the last two or three years. Its extensive adoption, however, was hampered by the rules in force on the railways relating to the weighing of consignments and to the return of empties. Through the good offices of the President of the Railway Board, these obstacles have been removed. Two suggested concessions for the fruit trade received the support of the Railway Board at the last meeting of the Railway Conference Association at Simla. These were that consignments of fruit should be grouped for purposes of charge and that returnable packages, approved by the North Western Railway, should be returned free of charge to Quetta, Gulistan or Chaman. This was agreed to by all the chief railways in India. During the present year the Agent (Sir Robert Gales) and the Traffic Manager (Mr. Boalth) visited the Fruit Experiment Station at Quetta and agreed to recommend to the other railways that the cardboard boxes as well

as the returnable crates should be returned free. These concessions are greatly appreciated by the fruit trade and are certain to help materially in the improvement of the industry.

5. The propagation of fruit trees.

When the development of the fruit industry in Baluchistan was first considered, the line of advance appeared to be in the direction of improved packing. It was argued that if the fruit at present produced could be sent to the more distant Indian markets and sold to advantage, the demand for such produce would increase and the extension of the area under fruit would follow. These anticipations have been realized and the demand for nursery stock is now very great and is likely to remain so for some years. To meet this, a considerable amount of attention has been paid during the last few years to working out the best methods of propagation under Quetta conditions.

Stocks. The first point taken up in 1911 was a study of stocks. For this purpose, all the possible stocks were collected in 1912 and planted out side by side in a special stock plot. The object of this was to compare their growth and behaviour under field conditions. To bring out any differences, a piece of land was selected which was not in a very good condition as regards tilth and fertility. Almost from the very beginning results began to accumulate. It was soon evident that the stocks used on the damp soils of Great Britain and the North of France were quite unsuitable for the hot, dry soils of Baluchistan. Stocks like the Black Damask and the Mazzard, which are so much used in Great Britain, are useless for Quetta. This at once explained why the peaches, nectarines, plums and apricots worked on the former which have been introduced in such large numbers from Europe in the past have not done well in Baluchistan even under garden conditions. Cherries budded on the Mazzard have only done well on the most favoured spots where the roots are least affected by the high temperature of the soil. On the other hand, such stocks as

the Mariana, Myrobolan, Mahaleb and the Jaune de Metz Paradise have done exceedingly well. Their behaviour shows them to be eminently suitable for Baluchistan. Among local stocks, the almond is the only one which is likely to be of much use. Having discovered the best stocks, the next point was to obtain a supply ready for immediate use. With only a few small trees of each kind available, it was impossible to raise large numbers locally. The experiment was tried of importing the stocks in bulk from Orleans. For the last three years this has been done successfully. Even the delays due to the war have resulted in remarkably few casualties as will be seen from the results of 1917 (Table II) when the delays in transport were very great.

TABLE II.

The importation of stocks from France in 1917.

Stock	No. ordered	No. established
Mariana	3,000	2,195
Myrobolan	3,000	2,784
Mahaleb	3,000	3,049
Pear	1,000	380
Jaune de Metz	1,000	411
Apricot	1,000	821
TOTAL .	12,000	9,640

This works out at over 80 per cent., a result which is considerably exceeded under more normal conditions of sea transport. The cost comes to about a penny for each established plant.

Management of nurseries. Having disposed of the stock question, the next point was to determine the best method of nursery management. In addition to the water supply, the limiting factors in growth were found to be two

—soil-aeration and soil-temperature. The soil-temperature factor can be kept in check by surface flooding when the soil is kept cool by evaporation. This, however, destroys the aeration and leads to poor growth. If the water supply is kept too low, the soil warms up and the roots of the young trees are affected by temperature. A satisfactory working compromise between the various conflicting factors has been tried for the last two years. To save water and to promote soil-aeration, furrow irrigation has been adopted. To keep the ground between the rows cool, the soil is mulched in May before the hot weather begins with a deep covering of a leguminous weed known as *busunduk* (*Sophora alopecuroides*). This has been found to be successful even with seedling apricots which are exceedingly sensitive to the high temperatures of the soil in June and July.

As the results obtained in the propagation of fruit trees at Quetta are likely to be of more than local interest in India, a bulletin dealing with these matters has been prepared for publication. It might easily pay in extending fruit culture in Kumaon, Kulu and Kashmir to import suitable stocks in bulk and to bud them locally. In this way, the initial expense in establishing orchards would be greatly reduced.

IV. Programme and Publications.

Programme of work for 1917-18.

Work will be continued on the following crops on the lines indicated in the annual reports and in the publications of the section—wheat, tobacco, gram, fibre plants, indigo, oil-seeds, fodder crops and fruit.

Publications.

The following papers were published during the year. In order to bring the list up to date, all papers in the press which are referred to in this report have been included :—

1. Third report on the improvement of indigo in Bihar. *Bulletin 67, Agricultural Research Institute, Pusa,* 1916.

2. The influence of the weather on the yield of wheat. *Agricultural Journal of India*, Vol. XI, 1916, p. 351.
3. The economic significance of the root-development of agricultural crops. A paper read at the Indian Science Congress, Bangalore, 1917, and published in the Special Science Congress Number of the *Agricultural Journal of India*, 1917.
4. The agricultural development of North-West India. A paper read at the Indian Science Congress, Bangalore, 1917, and published in the Special Science Congress Number of the *Agricultural Journal of India*, 1917.
5. Leguminous crops in desert agriculture. *Bulletin 6, Fruit Experiment Station, Quetta*, 1916. Reprinted in the *Agricultural Journal of India*, Vol. XII, 1917, p. 27.
6. The irrigation of alluvial soils. *Bulletin 7, Fruit Experiment Station, Quetta*, 1917. Reprinted in the *Agricultural Journal of India*, Vol. XII, 1917, p. 185.
7. The sun-drying of vegetables. *Bulletin 8, Fruit Experiment Station, Quetta*, 1917.

REPORT OF THE IMPERIAL MYCOLOGIST.

(E. J. Butler, M.B., F.L.S.)

I. Charge and Establishment.

I held charge of the Section throughout the year, and Dr. F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S., remained as Second Imperial Mycologist. Dr. Shaw was absent on a course of musketry instruction at Pachmarhi, under the Indian Defence Force Act, during April, 1917. Babu N. N. Mukerji was appointed second clerk in place of Babu N. C. Sen, from August 2nd. Mr. S. N. Mitra, Second Assistant, and Babu P. C. Kar, Fieldman, returned from service under the Military Department in Mesopotamia on November 16th and their work in the campaign against flies was well reported on by their superior officers. Dr. Shaw received the degree of D.Sc., for research in Botany, from the London University during the year and Mr. J. F. Dastur, First Assistant, that of M.Sc., with distinction, in Botany, from the Bombay University.

II. Training.

Mr. Deoki Nandan, B.A., M.R.A.C., attended the Section as a private student up to the end of September. Mr. S. C. Bose, Assistant to the Mycologist, Indian Tea Association, was given a special course in laboratory technique from April 16th to May 16th. Lala Kripa Ram, L.Ag., Assistant to the Economic Botanist, Punjab, has been undergoing a special course of training since April 18th, 1917. Mr. G. S. Cheema, M.Sc., Research Scholar of the Punjab University, was permitted by the University to commence research work on plant diseases in the Mycological Section at Pusa during the vacation. He remained from June 1st to 27th, 1917.

III. Mycological Conference.

A combined conference of Mycologists and Entomologists was held at Pusa in February. There were joint

meetings on the 5th, when the proceedings were opened by the Agricultural Adviser, and on the 9th, to discuss the Rome Phytopathological Convention of 1914; on the other days the Mycologists met separately, and the sittings terminated on the 10th. Practically all those interested in Economic Mycology in India attended and much useful work was got through. This was the first occasion on which an attempt was made to bring together all the workers in the science in this country; the response and interest taken in the proceedings were most gratifying; and it is hoped to arrange similar meetings at periodical intervals, as part of a larger scheme for sectional meetings to be discussed at the next meeting of the Board of Agriculture. A report of the proceedings is in the press.

IV. Diseases of Plants.

The investigation and the demonstration of methods of control of plant diseases formed, as usual, the major part of the work of the Section. Crop parasites were collected and identified and advice given to the officers of the Department and the general public as occasion required.

(1) Paddy diseases. The investigation of *ufra*, a disease caused by an eelworm, *Tylenchus angustus*, Butl., was continued, in collaboration with the officers of the Bengal Department of Agriculture. During the past year, it has been traced across the Meghna into the districts of Backerganj and Faridpur, extending westwards as far as the river Madhumati. The area now known to be infected is, from east to west, from the Mahari river, near the Chittagong border of Noakhali, to the Backerganj-Khulna boundary, and, from south to north, from near Noakhali town, to the Dacca-Mymensingh boundary. Extension into Mymensingh, Khulna and Sylhet is probably going on. The Collector of Dacca reported that part of the winter rice crop was so severely damaged on the eastern side of the Madhupur Jungle and near the Lakhya river that it was not worth harvesting.

Experiments carried on at Pusa have thrown light on several of the anomalies in the parasitism of the eelworm which causes *ufra.* It was previously known that the spring crop, called *boro* rice, and also the transplanted autumn and winter rice, ordinarily escape the disease under natural conditions, though they can be readily inoculated artificially. As the *boro* fields are often surrounded by severely infected fields of winter (*aman*) rice, they are certainly frequently contaminated by diseased stubble from the latter, and it was not easy to understand why they are not attacked. It has now been conclusively proved that the worm cannot migrate so as to reach the upper parts of the rice plant, where alone it can feed, in dry air, but does so readily when the humidity of the air approaches saturation point, even though there is no film of free water on the plants. It has also been found that worms preserved dry retain their vitality and are able to renew active motion after at least eight months, while those kept in moist air remain alive for about four months, and those immersed in water for only one to two months. The *boro* fields are submerged in water from the time the crop is transplanted into them in December-January, until near harvest. Worms set free into this water from previously infected stubble, will die unless they can migrate from the water within a couple of months. While the seedlings are small, no doubt some can migrate to them at or near the water level, but the injury caused to rice plants at this stage of growth is slight. As the plants get bigger, only certain parts near the top of the shoot (above the upper joints of the stem and the young ear chiefly) remain susceptible to attack, as only these parts have unthickened cell walls. But the worm is unable to reach them, owing to the low air humidity between February and April, and so the plants escape the serious damage that results from an attack on the shoot while the ears are developing. The crop is harvested in April, before the humidity rises enough to allow any worms that may still remain alive on the lower parts of the plants to migrate to the top of the shoot. It has also been found that the worm

does not reproduce if immersed in water or if kept dry, but only in moist air. There is therefore no multiplication of the parasite in the flooded fields nor amongst any that may get carried up on the growing *boro* plants. If the plants are covered with bell jars, so that the air around them is kept nearly saturated, infection can readily be obtained from artificial inoculations at any time of the year. If not covered, successful infections can only be got during the rains and early cold weather, while the natural humidity is high.

The escape of the transplanted paddy is due to the fact that it is grown on relatively high ground. The crop is harvested so that not much stubble is left, and the fields are ploughed early. It has been proved that worms set free into the soil do not remain alive long, and the new crop is not transplanted out until much after the period that has proved sufficient to free the soil from infection. If worms could reach the transplanted fields from neighbouring infected broadcasted fields, they would doubtless attack the transplanted paddy; but as a rule the flood water does not rise sufficiently to establish direct connection until relatively late in the season, and often not at all. That infection in this way does, however, sometimes occur is probable from the occasional reports that have been received of injury to the transplanted winter crop.

In certain parts of the infected area, the rice *bhils** are narrow and deeply concave. In the bottom of these, the soil remains muddy until February and, where deep-water *aman* has been grown, a second growth of small shoots and ears, arising from the long, matted stubble, can be found up to mid-February. In infected *bhils* this second growth harbours large numbers of actively feeding and multiplying worms. The ground does not dry out sufficiently to permit of ploughing until February in many cases, and the new crop has to be broadcasted very soon—in March—as the *bhil* bottoms flood early. Hence the worms have only about a month to live through before the new crop is sown and free

*Basin-like depressions which always hold water in the rains.

water collects, and about another two months before the humidity rises (in May) enough to permit of migration. Reports are common that the earliest attacks of *ufra* are seen in these low-lying patches, which is just what would be expected. It is not suggested that *ufra* always, or even frequently, arises from these low-lying patches, as it has been conclusively proved that the stubble in the paddy flats that dry out in December, as the great bulk of them do, is equally able to carry over infection to the next crop. But whereas it is relatively easy to remove the infected stubble and plough early in the latter, this cannot readily be done in the former. So long as the soil remains muddy, it is practically impossible to allow the work-cattle into it, and even if the stubble could be collected, it is too wet to burn properly in December. When the stubble can be removed and the land ploughed, it is so near sowing time that the chances of killing out the worm before the new crop appears are scanty. There appear to be only two ways of dealing with these muddy patches : to drain them so that they dry in time to permit of effective stubble destruction; or to deepen them so that they can grow *boro* paddy. The latter is only possible in the vicinity of permanent waterways or *khals*, as the *boro* crop has to be irrigated during its growth, but as these *khals* replace roads throughout much of the area, there is a general demand for new ones wherever practicable. Experiments have been started to ascertain the best way of dealing with this problem.

An attempt to induce the paddy cultivators to burn the stubble and plough early was made. Leaflets were distributed throughout the infected area and several demonstrations were arranged for, partly by the Department of Agriculture and partly by the revenue officials. In the Sadar Sub-division of Tippera, 12 previously diseased plots were treated, all of which escaped *ufra;* in Chandpur 64, of which 9 got slight attacks. There was less *ufra,* however, in this district than for several years. In Dacca the land selected was very swampy and the treatment was ineffective, probably for the reasons given in the last paragraph.

When the rice worm was first described (*Pusa Bulletin* No. 34, 1913) no other instance was known of injury to cultivated plants caused by an eelworm with the peculiar surface-feeding habits of *Tylenchus angustus*. Quite recently, however, a second case has been recorded, on currants, near Cambridge (England). It seems probable that others will be discovered, now that attention has been directed to the economic importance of this type of nematodes. An account of the present stage of the investigation is in preparation for publication.

(2) " Tokra " of tobacco and mustard. Further experiments were carried out by Dr. Shaw with the object of testing the claim that sodium nitrate was a specific against this pest. The results of the previous season's work had been partly obscured by the fact that the amount of " tokra " appearing in a plot seemed to depend as much upon the degree of infection in the soil as upon the influence of any application of sodium nitrate. During the season 1916-17, the experimental plots were so arranged, in the light of the information gained during the previous season, that this factor was eliminated. It was then found that the amount of "tokra" which came up in any particular plot depended largely upon the degree of infection in the soil and was practically uninfluenced by any application of sodium nitrate upon an agricultural scale.

The species of *Orobanche* examined were *O. cernua* Loeffl. and *O. indica* Ham. and, as in the previous season, the former proved to be restricted to *Solanaceæ* while the latter occurred principally upon *Cruciferæ* and only to a modified extent upon *Solanaceæ*. With a view to testing the parasitism of these species in greater detail than was possible within the limits of a field experiment, a series of pot cultures was carried out. Four host plants were used, namely tobacco, cabbage, mustard and turnip, and these host plants were infected with seed of *O. cernua* and *O. indica* which had been collected from " tokras " parasitic both upon the species of host plant infected and upon the other three host plants. Thus pots containing tobacco

plants were infected with seed of *O. cernua* collected from *O. cernua* upon tobacco and with seed of *O. indica* collected from *O. indica* upon mustard, from *O. indica* upon tobacco, from *O. indica* upon cabbage and from *O. indica* upon turnip. The same treatment was applied to mustard and to the other host plants. The results showed that *O. cernua* was strongly parasitic upon tobacco and did not attack the other three hosts, while *O. indica* was not parasitic upon tobacco unless the seed used had been collected from plants which were parasitic upon this host, in which case such seed was not capable of infecting mustard plants with "tokra." Seed of *O. indica* collected from plants parasitic upon either mustard, cabbage or turnip, however, would not infect tobacco but was strongly parasitic upon all of these hosts. Thus there appear to be two races or strains of *O. indica*, one parasitic upon tobacco and not infecting mustard and the other parasitic upon mustard, or the allied cabbage and turnip, and not infecting tobacco. Certain of the pot cultures received heavy applications of sodium nitrate, which, however, did not have any marked effect upon the occurrence of the tokras; the details and results of all the above experiments are now in the press.

(3) Phytophthora investigations. Mr. Dastur has continued his studies on this important genus. The Black Thread disease of Para rubber trees is fully described in the Memoirs and, as a result, the attention of other workers has been directed to the similar condition prevalent in Ceylon and Java. It seems clear that the disease is found in most parts of the East where rubber is grown, but the Java workers still hold that it is due to the same parasite that causes the well-known rubber canker, and is not a new disease. Mr. Dastur has given reasons for believing the parasite to be a distinct species, a matter of considerable economic importance since the canker fungus is common especially in the neighbourhood of infected cacao trees. He has found the Black Thread fungus to be much more restricted in its parasitism than *Phytophthora Faberi*, the canker fungus, and has quite failed to get it to attack cacao and other hosts

of the latter. The remedial measures recommended are being tested on a plantation scale in Burma. The chief are the free admission of light and air amongst the trees by judicious thinning, and the cessation of tapping during the monsoon months on all diseased trees. In South India, where the same or at least a closely allied disease is under investigation, good results have been obtained by the application of antiseptic and waterproof smears to the cut surface left after tapping. Tar and tallow; sulphur, cowdung and clay, have been used, and no doubt other more efficient mixtures will be found. It is not yet certain whether similar measures will be required in the relatively drier parts of the Burma rubber districts and, at the time of writing, Mr. Dastur is carrying out further enquiries in Burma.

A second Memoir contains an account of a biologic variety of *Phytophthora parasitica*, Dastur, found in Pusa on *Vinca*. It is a weak parasite, inoculations failing as a rule unless the atmosphere is almost saturated with moisture, but succeeding in damp air on a considerable number of garden plants. The fungus is, therefore, of more scientific than economic interest.

In a third paper, Mr. Dastur discusses the conditions influencing the distribution of *Phytophthora infestans*, the cause of the common potato blight. In India the fungus is ordinarily restricted to the Himalaya, Khasi and possibly Nilgiri Hills, but periodical outbreaks have been observed in the Gangetic plain and the valleys of Assam and Sylhet. An analysis of the conditions leading to these attacks, indicates that temperature, moisture and source of origin of the tubers are all important factors in controlling the distribution of the disease. Long exposure to temperatures above 77°F., is already known to be fatal to the fungus and such temperatures are usually found at the time of sowing the plains' crop. Furthermore, damp weather at the period of fructification of the fungus (January and February in the plains) is necessary to permit free reproduction and dissemination. And unless the tubers come from some already infected area, such as the Himalaya or Khasi Hills,

they are not liable to contamination and they will escape disease in the plains, since the plains' crop is normally free and local infection not usually to be feared. The outbreaks investigated showed that the seed used was probably infected, that it was brought from the Hills when the temperature below was under the normal for sowing time, and that the crop was exposed to rain or ground fogs as it ripened. Unless all these conditions are met, the crop may be expected to escape in the plains and in most of peninsular India.

(4) Rhizoctonia and other sclerotial diseases. A severe attack of *Rhizoctonia* on jute in the experimental plots on the Dacca Farm enabled the interesting observation to be made, in July, 1916, that plots which had received heavy fertilization were practically immune. As the experiment did not give any indication of the constituents which led to this result, a new series was laid down by Mr. Finlow, Fibre Expert to the Bengal Government, and in a recent report this officer states that the results strongly suggest that potash deficiency is the main cause of the severity of the disease on the old alluvium north of Dacca. The enquiry is being followed up in connection with the accumulating evidence that certain Indian soils are dangerously deficient in one or other of the essential constituents of plant-food, and that this deficiency may be manifested in increased susceptibility of the crop to fungus diseases. This point will be further referred to under " tikka " disease of groundnut.

From time to time reports and specimens of a serious root rot of cotton in northern and western India have been received. A local investigation in the southern Punjab, supplemented by a re-examination of the material in the Pusa collections, revealed a certain definite train of symptoms, enabling the disease to be recognized with certainty. Its cause is very obscure, several fungi being present on the roots of most specimens, but none so extensively nor so regularly as to be the probable cause. Two have been isolated for further work, a *Rhizoctonia* and a sterile, non

sclerotial form. Inoculations with the former, which is present on almost all diseased plants, but often apparently in very small quantity, were carried out at Pusa but under somewhat unsatisfactory conditions as the season was far advanced and the available plants old. They gave negative results. Further trials will be made with this and the second fungus. During the enquiry, we were again confronted with the probability that there was some condition connected with the chemical composition of the soil in which this root-rot occurred which was the predisposing factor. This condition may be a weak concentration of harmful alkali salts, but the evidence is contradictory in some aspects and further enquiry and experiment will be required.

Sclerotial diseases of sugarcane and paddy. Dr. Shaw continued his investigations on these diseases throughout the year in the laboratory at Pusa and during a tour to Sindewahi Farm, Central Provinces. The specimens originally received from the Central Provinces ultimately yielded two sclerotial fungi in culture. One of these was *Rhizoctonia destruens*, Tass. and the other has not at present been identified. This second form possesses a mycelium which is almost indistinguishable from that of *R. destruens* but its sclerotia are large, irregular, white bodies very different from those of *R. destruens;* both these fungi proved to be parasitic upon the leaves of sugarcane. At Sindewahi, however, it was obvious that the most serious parasite was the second, unidentified, sclerotial fungus. This occurred all over the farm on scattered clumps of cane and resulted in the complete death of the outer leaves. The early stages of attack appeared as red spots on the leaf sheath, the inner side of the leaf sheath being covered with a thick sugary solution containing a fungal growth. As the spot spreads the mycelium forms a thick crust on the interior of the leaf sheath and the sugary solution dries up. Finally the leaf is left as a dry and withered scale and sclerotia are produced along its edges. Cultures were obtained at Sindewahi from the mycelium on the leaf, from sclerotia on the leaf, and from sclerotia in the soil. In

every case the same organism was produced in culture and inoculations with these cultures have been successful in producing the disease upon canes at Pusa. The hyphae appear to enter the leaf through the stomata and penetrate the tissues of the leaf in all directions; microscopic work on this subject is proceeding. The disease appears to be very similar to that known in Java under the name of "Het zuur Rot."

Specimens of a different sclerotial disease of sugarcane were received from Eastern Bengal during the year and appeared to be identical with the disease which is known in Java as "Djamoer Oepas." In this case very characteristic light brown spots with a dark margin occurred on the blade of the leaf together with a fungus having a brownish mycelium and irregular brown sclerotia. Both the parasitic organism and the resulting spots on the leaf were very similar to the sclerotial fungus and the leaf spots described below upon paddy.

The fungus *Sclerotium Oryzæ* Catt. was very prevalent upon specimens of diseased paddy from the Central Provinces, and associated with *S. Oryzæ* on these specimens a second sclerotial fungus was found. This latter form possessed small brown spherical sclerotia, very regular in shape and size. The fungus was obtained in culture and its parasitism upon paddy is being investigated.

Paddy in Pusa sometimes suffers from the attack of another species of sclerotial fungus with large, brown, irregular sclerotia and hyphae of the *Rhizoctonia* type. This fungus causes very distinctive spots upon the leaf sheath; these spots when mature have a light brownish central area surrounded by a dark red brown line, the central portion consists of dried and dead leaf tissue and the darker margin probably represents the active zone of the fungus. The external symptoms resemble very strongly those of the sclerotial disease of sugarcane from Dacca, and it is possible that the causal organism in the two cases is the same, but the present fungus on paddy has several points of agreement with the species *Sclerotium irregulare*, described by

Miyake as parasitic on leaf sheaths of paddy in Japan. This fungus has been obtained in culture and successful inoculations in Pusa have succeeded in producing the typical leaf spots. Further research is in progress to determine the method of parasitism and the extent of damage resulting to crops.

Several other sclerotial diseases of minor importance were observed during the year, among which the most serious were an attack of *Rhizoctonia destruens*, Tass. upon wheat and lentil (*Lens esculenta*) in Burma, and a collar rot of lemon seedlings at Nagpur caused by an unidentified species of this genus, which is also parasitic upon chilli and *Hibiscus* in Pusa. All of these fungi have been obtained in pure culture and are being studied.

(5) Anthracnose of chilli and pulses. The serious disease of chillies in Bihar, referred to *Colletotrichum nigrum* E. and Hals. in last year's report, has been found to be due to an allied but distinct fungus *Vermicularia Capsici*, Syd. The former is a North American fungus and was found to be different from the Bihar species on comparison by the mycologists of the United States Department of Agriculture, who have, as usual, given us every assistance. Subsequently the true *Colletotrichum nigrum* was found in Burmese specimens, while a third form, *Glomerella* (*Gloeosporium*) *piperata*, S. & v. S. occurs sporadically throughout India. It appears to be better to restrict the term anthracnose to these two last-named (possibly only different forms of the same fungus) and to call the disease caused by *Vermicularia* " die-back," from its most prominent symptom, the withering back of the top shoots of the plant. Mr. Dastur has carried out a more detailed study of " die-back," which it is hoped to publish during the coming year. Meanwhile experiments in its treatment are in progress. The results anticipated from the seed selection referred to in last year's report have not materialised : disease was almost as severe in the plot grown from selected as in that from non-selected seed and it is evident that the fungus does not rely on seed-infection to

secure its perpetuation. Fortunately it seems that control by spraying will be relatively easy and a detailed series of experiments has been laid down to test spraying during the present season.

The same *Vermicularia* has been found to be one of the causes of a disease of various pulses, such as cowpea and Dolichos, and of Solanaceous plants, such as tomato and brinjal. As in chillies, it has been previously confused with the anthracnoses of these crops, but it seems to be of relatively minor importance on these hosts. It has not yet been recorded outside India, except in the Philippines.

(6) " Tikka " disease of groundnut. An outbreak of this disease on the Ranchi Farm was investigated. The soil of this farm is singular in being almost devoid of sulphur, and is also markedly deficient in phosphorus. It appears from analyses carried out in Bombay that groundnuts require relatively large quantities of the latter constituent, and as the nuts mature there would seem to be a heavy drain on the phosphates of the soil. It was observed by Mr. Dobbs, Deputy Director of Agriculture, Bihar and Orissa, that at this period the disease set in and developed with great intensity. Experiments have been arranged by Mr. Dobbs this season to test the view provisionally arrived at that "tikka" disease may be symptomatic of deficiency in available phosphates, in other words may be a deficiency disease similar to jute *Rhizoctonia* as described above.

(7) Sal tree disease. The investigation on the root rot of the sál tree was continued by Dr. Shaw during the year, efforts being principally directed towards completing the life history of the fungus in artificial culture and establishing its parasitism upon the sál by means of direct infections. With this latter object, a series of inoculations was carried out in June, 1916, at Rajabhatkhawa and in August, 1916, at Dehra Dun. The inoculations at Rajabhatkhawa were examined in December last and failed to yield conclusive results. In the case of one of the trees which had been infected with cultures of *Polyporus Shoreæ*, the disease was found to be well established, but it was obvious that this

was the result of a natural infection from two neighbouring trees which had since died. In fact it is most probable that this tree was already infected in the lower roots when the inoculations were made in June, 1916, but that the disease had not at that time spread sufficiently near the surface of the soil to be visible or produced sufficiently marked external symptoms to enable the tree to be distinguished from its apparently healthy neighbours. This case serves to call attention to a great difficulty in the work at Rajabhatkhawa, namely, the impossibility of knowing whether a particular tree is or is not infected with the disease. The final stages of the disease are easily identified, the defoliation and death of the tree being accompanied by the production of a large fructification and the presence of " partridge wood " in the whole of the external tissues of stem and root in the region of the ground level. A little earlier than this however the tree appears quite healthy, and the diseased tissues can only be found at a point about 1 foot below the ground level, or perhaps diseased tissues may only be discovered by going down to a depth of 6—8 feet. It is therefore impossible to say that a tree is free from infection until the bulk of the roots have been laid bare, after which it is hardly a fair subject for inoculation experiments. This objection does not however apply to the infections carried out in collaboration with the Forest Botanist at Dehra Dun and it is hoped that these may yield more decisive results; arrangements have been made to examine them in September, 1917.

It is worth noting here that in diseases of large trees caused by Basidiomycetous fungi, the parasitism of the causal fungus has not invariably been established by the method of direct inoculation, the constant association of the fructification of the fungus with the symptoms of the disease and the presence of the mycelium in the tissues being, in some cases, the only direct evidence of the parasitism of a particular species. From this point of view some interesting information and figures should in a few years be obtainable from the " fungus observation areas " in the

Buxa Division. Even now, after only two years' continuous observation, it appears that the fungus is spreading rapidly and that the death rate of trees on which the fungus occurs is, in some plots, high : this rate however shows considerable variation from one plot to another. It must be remembered that in a slow growing forest crop such as sál, a low yearly percentage of loss, which in the case of an annual agricultural crop would be negligible, may be very serious.

(8) Peach leaf curl. This disease has long been the cause of serious loss in the important fruit-growing districts of North-West India and until recently was not considered susceptible of treatment by spraying, the relatively unsatisfactory methods of pruning and burning diseased branches being the only remedial measures advocated. Experiments conducted in America have however shown that the spread of this parasite—*Exoascus deformans*, (Berk.) Fuckel—by air-borne infection plays a very extensive part in the spread of the disease and that spraying with Burgundy mixture just before the buds open is an effective control against this trouble. In co-operation with the Agricultural Officer, North-West Frontier Province, an extensive trial of this method was carried out in the Government Orchards at Taru during January, 1917, with results which have proved very encouraging, there being a considerable difference between the sprayed orchard and neighbouring private orchards. Trials were made both with lime-sulphur mixture and Burgundy mixture and both proved satisfactory. Owing however to the ease with which it can be prepared, the latter will be the most popular with the cultivator. Spraying is to be continued at the Government Orchards during future seasons and it is hoped to introduce the practice to fruit-growers in the district and to lessen materially the damage done by this destructive disease.

(9) Other diseases of interest. The powdery scab of potatoes caused by *Spongospora subterranea*, (Wall.) John., was received from Bombay Presidency. This is the first record of any parasitic member of the Myxomycete family

in India and the first time any potato scabbing organism—common though they are in the West—has been found in this country. A considerable amount of time was given to the identification of tea and coffee parasites sent in by the officers of the Planters' Associations concerned or personally collected in previous years. In tea, Mr. Tunstall, Mycologist to the Indian Tea Association, has taken up the study of the numerous root diseases, and amongst the material he sent in was found *Sphærostilbe repens*, B. and Br., now first recorded as a tea parasite, and *Rosellinia bothrina*, (B. and Br.) Sacc. not previously known in India but found on tea in Ceylon. In coffee it was found that the Java "spider's web" disease and the widely distributed brown eye-spot disease (*Cercospora coffeicola* B. and Cke.) both occur in India, but are apparently uncommon. The suspected parasite *Pythium gracile*, Schenk, occurred on young tobacco, and Babu L. S. Subramanium was able to get it into culture, thus allowing of an accurate examination of its parasitic tendencies. So far it has been proved to attack ginger rhizomes readily, causing the soft rot disease which was described in the *Agricultural Journal of India* (Vol. VI, 1911, p. 139), as prevalent in Rangpur and Surat. It is also parasitic on tobacco and probably other crops. It is hoped to publish an account of this work shortly. Experiments with the smut of *bajra* (*Pennisetum typhoideum*) established that this disease is not influenced by rotation of fields, thereby suggesting that it is seed-borne. Attempts at seed disinfection have, however, failed. An apparently new disease of paddy due to the attack of a species of *Cephalosporium* or *Verticillium* was received from Lyallpur. The fungus is being studied and inoculations have been tried. The damage at Lyallpur was estimated at 15 per cent. of the crop and it is possible that a new and serious parasite of paddy has been discovered.

V. Miscellaneous.

The problems connected with international legislation against plant diseases, continued to engage attention. In

order to establish the scientific basis on which legislation must rest, an examination of the factors controlling the dissemination of parasitic fungi has been completed and published. Two types of dissemination should be distinguished: continuous or short-range, and discontinuous or long-range. For the former, fungi are so well equipped that measures to check it are likely to prove abortive: for the latter, on the other hand, a great body of evidence has been got together to show that, if we exclude human agency, fungi are not in a position to make such considerable jumps as to be able to cross the seas or spread from one part of the world to another at all readily. Most of the important plant diseases that have appeared in recent years can be traced to the movement by human agency of the living plant which they attack, from one part of the world to another; they follow trade routes; and when, one after another, the more isolated parts of the world are brought into contact with western civilization and opened up to trade and exploration, each lets loose its indigenous pests and diseases to infect the countries with which commercial relations become established. It is not realized how thoroughly new countries are searched for economic plants, nor how quickly attempts are made to introduce novelties, or even varieties of already cultivated kinds, from them. It is open to question whether the benefits gained from such sources are not more than counterbalanced by the new diseases that have thus been introduced.

The book on fungi causing crop diseases in India, referred to in last year's report, has been completed and is now in the press. It deals with the general principles of plant pathology and gives a detailed account, crop by crop, of the more important diseases of cryptogamic origin found in Indian field and plantation crops.

VI. Systematic Work.

This has been largely in abeyance during the year, partly owing to the difficulty of obtaining foreign assistance under present conditions. Several collections have been identified

for officers of the Agricultural and Education Departments and for others interested in Mycology. Several pathogenic species of *Aspergillus* have been sent in from the Institute of Analyses and Vaccines at Nova Goa (Portuguese India), and the interesting discovery was made that the fungus habitually found in heart-damaged bales of jute is *Aspergillus fumigatus*, Fres., already known to occur in Indian soils and to be, in other countries, a not uncommon cause of ear and lung disease in man. The new additions to the Herbarium amounted to 450 sheets.

VII. Programme of work for 1917-18.

(1) *Research work.* New diseases of Indian crops that come to the notice of the Section will be investigated as opportunity permits, but the following diseases will receive special attention and will constitute main lines of investigation.

(*a*) "Ufra" of paddy.
(*b*) *Orobanche* of tobacco and mustard.
(*c*) "Die back" and anthracnose of chilli.
(*d*) Sclerotial disease of sugarcane and paddy.
(*e*) Root rot of sál tree.
(*f*) Wilt diseases of cotton, sesamum and gram.

Minor investigations will include the study of some fruit anthracnoses, of the soft rot of ginger and of the root rot of cotton.

It is hoped to publish a hand book of diseases of crops.

(2) *Systematic work.* This will be in abeyance for the present owing to difficulties in obtaining assistance from abroad on account of the war.

(3) *Training.* This will be continued on the lines indicated in the prospectus. Short courses may also be given as necessary.

(4) *Routine work.* Advice and assistance will be given as usual to Provincial Departments of Agriculture, the Forest Department, Planters' Associations and the general public.

VIII. Publications.

(1) Butler, E. J. . Report on Mycology, 1915-16, for the Board of Scientific Advice.

(2) Dastur, J. F. . *Phytophthora* sp. on *Hevea brasiliensis*. *Mem. Dept. of Agri., India, Bot. Ser.*, Vol. VIII, No. 5.

(3) Dastur, J. F. . *Phytophthora* on *Vinca rosea*. *Mem. Dept. of Agri., India, Bot. Ser.*, Vol. VIII, No. 6.

(4) Butler, E. J. . The Dissemination of Parasitic Fungi and International Legislation. *Mem. Dept. of Agri., India, Bot. Ser.*, Vol. IX, No. 1, February, 1917.

(5) Dastur, J. F. . Conditions influencing the distribution of Potato Blight in India. *Agri. Jour. of India*, Special Science Congress Number, 1917.

(6) Shaw, F. J. F. . *Orobanche* as a parasite in Bihar. *Mem. Dept. of Agri., India, Bot. Ser.*, Vol. IX, No. 3. 1917.

Proceedings of the Mycological Conference held in February, 1917.

REPORT OF THE IMPERIAL ENTOMOLOGIST.

(T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S.)

I. Charge and Establishment.

The Imperial Entomologist held charge of the Section throughout the year ended 30th June, 1917. The post of Supernumerary Entomologist remained vacant throughout the year owing to the impossibility of obtaining any suitable candidate under present conditions. Mr. Y. Ramachandra Rao, M.A., Entomological Assistant in Madras, was deputed from 16th November, 1916, to work under the Imperial Entomologist for a period of two years in the first instance, to investigate the insects which occur on *Lantana* in India and Burma. Mr. C. S. Misra, First Assistant, was on privilege leave from 1st to 16th July, 1916, and again on privilege leave combined with medical leave from 24th January, 1917, to the close of the year under review. Mr. C. C. Ghosh was on privilege leave from 12th October to 15th November, 1916, and Mr. D. Nowroji from 12th October to 16th November, 1916.

D. P. Singh, Fieldman, P. Narayanan, Artist, and T. V. V. Subramani, Typist, were lent to the Military Department for Fly Control work with the Expeditionary Forces in Mesopotamia. They left Pusa on 5th July, 1916, and returned in November.

H. H. Prasad, Sericultural Fieldman, was lent throughout the year to the Imperial Agricultural Bacteriologist to assist this officer in his investigations of Pebrine.

II. Tours.

The Imperial Entomologist was on tour in Madras from 4th to 20th December, in Bengal from 5th to 10th January, and in the Central Provinces from 20th to 29th March. Mr. G. R. Dutt was on tour in Bombay from 26th February to 18th March and was accompanied by Sardar Harchand Singh, a student under training, to study crop-pests. Mr.

M. N. De, Sericultural Assistant, toured in Madras and Bombay from 23rd December to 9th January. The Fieldmen were sent on tour as occasion required throughout the year, chiefly in connection with outbreaks of pests.

III. Training.

Two students were under training in Entomology at the commencement of the year under review. Of these, Sardar Harchand Singh, deputed by Patiala State, completed the full course, and Deoki Nandan, a private student, discontinued the course from December, 1916, on appointment to the Agricultural Department. A short course of practical training in collecting, rearing and control of insects was also given to Safdar, a Fieldman, sent by the North-West Frontier Province.

IV. Insect Pests.

Numerous observations on Insect Pests have been made during the year but these cannot be given in detail here without unduly swelling this Report. Particular attention has been paid to the pests of sugarcane and of stored grain and the more important observations are noted below :—

1. Cotton. The experiments, referred to in last year's Report, were continued and tabulation of results has been taken in hand. Breeding of parasites of cotton bollworm (*Earias* spp.) was continued and living parasites were despatched to the Punjab in July and August, 1916. Specimens of these parasites were sent to Mr. Brues, who informs us that they belong to the genus *Microbracon*, and not *Rhogas* as previously supposed.

2. Rice. The life-history of *Nephotettix bipunctatus* was worked out. A Tubificid worm was sent in from Hmawbi, Burma, as damaging rice, but does not seem to be of regular occurrence as a pest.

3. Sugarcane. Considerable attention has been paid during the year to the important subject of borers. Hitherto several different species of borers, all superficially very much alike, have been mixed together under the name

of Moth Borer (*Chilo simplex*), which was supposed to attack sugarcane, maize, *juar* (*Sorghum vulgare*) and rice. An attempt was made to find out whether there were really one or several species concerned. As a result the following species have been discriminated up to the time of writing this Report, *viz.*:—

(1) *Chilo simplex*, found in maize, *juar* and rice.

(2) *Diatræa suppressalis* (*auricilia*), found in sugarcane principally. A few only have been found in *juar* and none in maize.

(3) *Diatræa venosata* (*striatalis*), found in sugarcane and a thick variety of *juar*, and none in maize.

(4) *Diatræa* sp. There is one unidentified species found in sugarcane only. It was reported some years ago from Pabna and has recently been found at Dacca.

All the above forms had hitherto been spoken of as *Chilo simplex*. Besides these, there are:

(5) *Papua depressella*, which, as reported last year, had hitherto been known as a rootborer. But as will appear from the figures given below, it proves to be the most injurious of all the borers in the young stage of the sugarcane, its activities becoming less as the cane grows.

(6) *Scirpophaga xanthogastrella* (*auriflua*), which is one of the first borers to attack the young cane. It is active in cane throughout the year.

(7) *Sesamia inferens*, which is known to occur in maize, *juar*, sugarcane and rice and several other plants of the Order Gramineæ.

This year a careful watch has been kept on the time of occurrence of all the above borers and an attempt has been made to find out the extent of damage which they cause.

On the Pusa Farm about 4¼ acres are under thick varieties of sugarcane, *viz.*, Purple Mauritius (half-an-acre), Sathi No. 131 (a little more than two-and-three fourths

acres) and Sathi No. 15 (a little less than one acre). There are also very small plots of other thick varieties, *e.g.*, Kaludaie Budhan, Dacca Cane, D·99 and Ashy Mauritius. A little more than one acre is under 21 different varieties which are classed as thin canes but some of them, *e.g.*, Meneria, might be described as of medium thickness. Of the half acre under Purple Mauritius $\frac{1}{4}$ acre was planted in November 1916; the other half of the Purple Mauritius and all the rest were planted in February, 1917. The plot of Purple Mauritius has been specially grown for entomological observation and experiment and this cane has always been critically examined while the others have been superficially examined for comparison of results. All the time the sugarcane has been in the field there have been maize and *juar* growing somewhere in the Farm. The progress of the insects in sugarcane, maize and *juar* has been carefully watched and is briefly described below. Red Rot in sugarcane has necessarily come under observation and there has been a good opportunity of comparing the damage caused by it with that caused by insects.

In the middle of April the plants of the plot of Purple Mauritius planted in November were slightly ahead in growth of those of the plot planted in February, but the difference in growth did not indicate a difference of about four months in planting. The damage noticed about this time was almost wholly due to insects and the damage in the former plot was 6·3 per cent. while in the latter plot it was 2·3 per cent. Taking both the plots together, of the total damage:

Scirpophaga xanthogastrella was responsible for 1·7 per cent.

Diatræa suppressalis for 2·3 per cent.

Gryllotalpa africana for 0·1 per cent.

Red Rot for 0·22 per cent.

All the affected plants were cut out and destroyed with the insects. All this time *Chilo simplex* and *Sesamia inferens* were abundant in Rabi maize and in a very small extent in Rabi *juar*.

In the second week of May the plot of Purple Mauritius planted in November was damaged to the extent of 8·9 per cent.—

Papua depressella being responsible for about 5·8 per cent.

Red Rot being responsible for about 1·1 per cent.

Termites being responsible for about 0·8 per cent.

Diatrœa suppressalis being responsible for about 0·66 per cent.

Scirpophaga xanthogastrella being responsible for about 0·52 per cent.

There was one shoot damaged by *Gryllotalpa africana* and two shoots damaged apparently by Red Ants. At this time there was no difference noticeable in the growth of the plants.

In the third week of May the plot of Purple Mauritius planted in February was damaged to the extent of about 11·5 per cent., the following being responsible for the damage :

Papua depressella about 8·1 per cent.

Red Rot about 2·27 per cent.

Diatrœa suppressalis about 0·7 per cent

Termites about 0·41 per cent.

Scirpophaga xanthogastrella about 0·06 per cent.

There was one shoot apparently damaged by Red Ants.

All the affected plants were cut out and destroyed with the insects in both the plots.

About this time (*i.e.*, second and third weeks of May) all the other plots of sugarcane were also examined to note the extent of damage, though the affected plants were neither cut out nor critically examined to find out the agent of damage as was done with the Purple Mauritius plants. The damage was however similar in all external appearances and the agents would most probably be the same as observed in the case of the Purple Mauritius.

The damage in Sathi No. 131 was 7·5 per cent.

The damage in Sathi No. 15 was 9·6 per cent.

The damage in Meneria was 10·6 per cent.

The damage in all the other 25 varieties, mostly thin, taken together was 9 per cent.

It would appear that the damage in these plots was about the same as in the Purple Mauritius plots from which all affected plants had been cut out and destroyed with the insects in April.

Throughout May *Chilo simplex* and *Sesamia inferens* were feeding in Rabi maize and to a very small extent in Rabi *juar*.

In the latter part of June the damage in the Purple Mauritius plot was about 25 per cent., the following being responsible for it :—

Red Rot about 15·4 per cent.

Papua depressella about 6 per cent.

Diatræa suppressalis about 2·2 per cent.

Scirpophaga xanthogastrella about 1·1 per cent.

Termites about 0·2 per cent.

Sesamia inferens about 0·06 per cent.

A few *Diatræa venosata* were found at this time.

All affected plants were cut out and destroyed with the insects.

About this time the damage in Sathi No. 131 was about 10 per cent. As far as could be judged by external examination, about 3·5 per cent. was due to Red Rot and about 6·5 per cent. to insects.

Sathi No. 15 suffered to the extent of about 8 per cent., damage due to Red Rot being about 2·5 per cent., and that due to insects being about 5·5 per cent.

Damage in Meneria was about 14·3 per cent., Red Rot being responsible for about 11 per cent. and the insects for about 3·3 per cent.

The damage in the other (mostly thin) varieties taken together was about 7 per cent., Red Rot being responsible for about 3 per cent. and the insects for about 4 per cent.

About this time *Chilo simplex* was practically absent from maize and *juar*.

The points to note are the following :—

(1) The high percentage of damage by Red Rot.

(2) In the Purple Mauritius plot all affected plants had been cut out once in April and again in May. Still the amount of damage due to insects in June was greater than in any of the other plots. It is probable that Purple Mauritius is more liable to damage by insects than the other varieties. In order to test the effect of this treatment of cutting out affected shoots further experiments will be undertaken next year with a single variety. This year's experience however leads us to believe that the only insect which will be amenable to this treatment is *Scirpophaga.*

Now that the other borers can be distinguished and therefore their habits definitely studied, other methods of control will have to be found out by further study and experiment.

Other insects observed for the first time to feed under ground among sugarcane roots include—

Alissonotum piceum grubs.
Alissonotum simile grubs.
Myllocerus blandus grubs.

A Melolonthid grub (probably *Anomala* sp.) has been observed definitely to gnaw into sugarcane stems from the side, causing a dead heart in the case of young shoots or killing the shoots and young plants. The grubs are still feeding and have not yet been reared.

Myllocerus discolor grubs have been found commonly among sugarcane roots.

The search for Coleopterous larvæ among sugarcane roots has been continued and several Chrysomelid and weevil grubs have been found which are still feeding at the time of writing this report.

As reported last year, termites have been observed to cause more damage to new shoots than to setts. Further observation confirms the view that it is only in particular

soils that termites cause damage to sugarcane setts and shoots.

An experiment was undertaken in an area which is known to be very much infested by termites to find out the strength of Lead Arsenate solution which would be suitable for dipping the setts in order to protect them from termites. Lead Arsenate manufactured by the Thomsen Chemical Company was used. A strength of 1 lb. in 2 gallons of water has been found satisfactory. Even a strength of 1 lb. in 1 gallon of water can be used without any harmful effects on germination. Weaker strengths up to 1 lb. in 4 gallons water are also effective.

4. Maize. The larvæ of *Heliothis obsoleta* caused a curious form of damage by boring into the tender top portion of the stem.

5. Fruit Flies. Large numbers of Fruitflies have been reared in the quest for parasites, but with little success. At Pusa *Chætodacus cucurbitæ*, for example, appears to be almost free of parasites, although in Southern India it is attacked by *Opius fletcheri*, which has been introduced from India into Hawaii with considerable success. *Carpomyia vesuviana*, however, is parasitized extensively and further consignments of living pupæ were sent to Italy in the endeavour to introduce these parasites there. An important paper by Professor Bezzi, on the Fruitflies of the genus *Dacus* occurring in India, Burma and Ceylon, has appeared during the year, the information contained in it being largely based on material sent from Pusa. Professor Silvestri has also described several Braconid parasites of Indian Fruitflies and has published a note on the occurrence of *Dacus oleæ* in India and also a description of its parasite in North-West India.

6. Life-histories of insects. In the Insectary more than 200 different lots of insects were reared and observations made on their life-history and habits as far as possible. Of these, many were new to Science and practically none had been reared before. Several of them may be ranked among pests and may be serious occasionally, for

instance, (1) a Cerambycid borer of Sann-hemp. The beetle girdles the stem and deposits the egg inside the stem The apical portion of the stem beyond the girdle dries. The grub bores inside the plant which dies. (2) A Cerambycid borer of *Phaseolus aconitifolius.* This also similarly causes the plant to die. (3) A Dermestid beetle which infested and destroyed some stored snake skins. (4) *Anobium* sp. in stored Cumin seeds and Aniseeds. It proves to be a serious pest of these seeds in store.

Investigations into the life-history and habits of the pests and other insects were continued. The important points observed with regard to some of them are noted below :—

Pea stem fly. Three different varieties of peas were grown in the Insectary compound, some mixed with barley and others alone, for carrying on observation with regard to *Bruchus affinis.* Incidentally it was observed that those which grew alone and thinly were damaged by the stem fly while the others escaped.

Eugnamptus marginatus was kept under observation throughout the year in the Insectary as well as outside on an affected mango tree. The grubs have been observed to rest in the soil from about September to March-April. The beetles are active mostly in July and August although some may be observed before and after this period of greatest activity. Although the grubs were resting in the Insectary, one beetle was found laying eggs and cutting leaves in March, but under the climatic conditions in Bihar the grubs had no opportunity of developing as the cut leaves dried quickly; some of these eggs were collected and reared in the Insectary, but only two attained the adult stage, one in April and one in May, and the others were resting at the time of writing the report.

Heliocopris bucephalus. A complete cycle was obtained in the Insectary. The beetles appear in the months of June to September but mostly in July. The grubs take about a year to grow.

Attagenus piceus has been observed to take one to three years to complete its life-cycle.

Hieroglyphus banian. In the Insectary there is a cage into which a pair was introduced in 1905. Since then they hatch out regularly every year in that cage and are fed and allowed to oviposit. The broods have been observed to extend gradually. Last year (1916) they hatched in June and the last of the adults died on 15th February, 1917. Of course different batches of eggs hatched at different intervals up to August.

Some individuals of *Polytela orientalis* have been observed to rest for the whole year in the pupal stage, whilst others emerged in the first year.

Melittia eurytion, which bores and causes a swelling in the stem of *Trichosanthes dioica* and other cucurbitaceous plants in the Rains, has been observed to rest for the remainder of the year in the larval stage inside a very stiff cocoon.

Cosmopteryx manipularis, a miner in bean leaves, has been observed to rest in the larval stage from about November to July.

The Cerambycid borer occurring in *Phaseolus aconitifolius* stem in the Rains, has been observed to rest for the remainder of the year in the larval stage.

Oides bipunctatus has been observed to have only one generation in the active season in the Rains, the rest of the year, as reported before, being passed in the egg stage.

The Eurytomine Chalcidid grub in apricot seed probably rests for two years inside the seeds in some cases, although most come out as adults after one year. In the Insectary some grubs were observed to rest for about a year and a half and then die.

Agrypnus fuscipes. One grub about one-third grown was collected in November 1914. It lived and grew in the Insectary since then, being fed wholly on Scarabæid and other similar grubs. It pupated and emerged in June, 1917, after living for about 2½ years in the Insectary. The life-cycle therefore seems to take about three to four years.

Odontotermes assmuthi. Colonies were established in artificial cages in July but all died by about October. In

the cages buried in the Insectary compound no colony lived for the whole year.

Lampyris marginella has been found, by observation outside, to have probably one generation in the year.

Ancylolomia chrysographella hibernates in the larval stage from about November to about March-April. Then it has several broods, each cycle taking about a month. It has been observed to breed mostly among wild grasses.

Aspongopus brunneus has been observed to cause serious damage to pumpkin plants. A cycle was observed of this insect.

Massepha absolutalis and another Pyralid rolling bamboo leaves have been observed to rest in the larval stage in winter and summer.

Pyrausta machœralis has been observed to hibernate in the larval stage.

Complete cycles were observed of *Pericallia ricini*, *Amsacta moorei* (form *sara*), *Hister* sp. and a Halticid beetle on *Anisomoles ovata.*

Pempheres affinis, the cotton stem weevil, has been observed to breed in a new foodplant *Triumfetta* sp. (N. O. Tiliaceæ).

Polyommatus bœticus has been observed to breed in the flowers of *Butea frondosa* (Palas) in such large numbers as to be reckoned as a pest of these flowers.

7. Grain storage experiments. The storage experiments were continued and the results so far obtained are briefly noted under different heads.

(*i*) *Wheat.* Many of the results which promised success on the first year's trial on a small scale were upset when tried on a medium storage scale this year. But some important differences were observed in the habits of the two principal pests we have to deal with at Pusa, *i.e.*, *Calandra oryzœ* and *Rhizopertha dominica*. *Rhizopertha* cannot breed when there is free access of air, but under the reverse conditions (*e.g.*, in earthen vessels with their mouths plastered up with mud) it is capable of doing much more damage and that in a much shorter time than *Calandra oryzœ*

Air and light retard *Calandra oryzæ* and if one can take the trouble of exposing the grain to air and light at frequent intervals very little damage is done. But this is not practicable when large quantities have to be stored.

In the light of this experience wheat has been stored this year under a method of outdoor storage in granaries made entirely of straw. In this condition the grain will remain exposed to the natural changes of climate and is not expected to be susceptible to attack by *Rhizopertha*. It remains to be seen whether *Calandra oryzæ* also is retarded. If successful, this method will be applicable to storage in bulk as well as in small quantities. At the same time arrangements have been made to give a satisfactory trial to the method of storage under sand.

(*ii*) *Rice*. The lime treatment of husked rice has been continued and it is giving the satisfactory result reported last year.

(*iii*) *Pulses*. Pulse seeds have to be protected in store against *Bruchus chinensis* which has been observed to breed in the larger varieties of peas (*Pisum sativum*), *arhar* (*Cajanus indicus*), lentil, *khesari* (*Lathyrus sativus*), *mung* (*Phaseolus radiatus* and *P. mungo*), *bora* (*Vigna catjang*), *bakla* (*Vicia faba*) and gram, and cause serious damage to them. Keeping the seeds covered with sand, coarse or fine, has given the best result, the seeds remaining in good condition and perfectly safe.

A species of *Bruchus* has been found to damage bean seeds in store in the same way as the above. The same method of storing under sand is applicable.

The small pea (*Pisum arvense*), as reported previously, is not liable to be damaged by *Bruchus chinensis* in store. But it is infested by *Bruchus affinis* in the field. This was dealt with in the last year's report. A system of sunning the harvested seeds has been tried this year and the result remains to be seen.

(*iv*) Besides the insects mentioned above, of the others which are found in stored wheat and rice, (1) *Tribolium castaneum* and (2) *Tenebroides mauritanicus* are very com-

mon, but they are always found in company with *Calandra oryzæ* and *Rhizopertha dominica.*

Tribolium has been observed to occur with *Rhizopertha* more than with *Calandra* and some experiments have been undertaken to find out its status definitely.

This year there was an opportunity of following *Tenebroides mauritanicus* throughout the year and of finding out its true status. It is found commonly with *Calandra oryzæ.* It takes about a year to complete the life-cycle, the adult beetles appearing and laying eggs in July-August and the rest of the year being passed in larval stage. The adult beetles live for several months and prey upon *Calandra oryzæ* weevils. The grubs do not attack the weevils but bore wheat and rice grains.

In the report for the year 1914-15, it was stated that *Tenebroides mauritanicus* on the whole played a beneficial part and its presence in affected wheat and rice would be beneficial. Further study has shown that the good the adult beetles do by preying upon the weevils is practically of no help. The real damage to wheat is done by the weevils from July onwards and *Tenebroides mauritanicus* is present at this time only in the larval stage and does not attain the adult stage till the next year. Also the beetles do not appear in sufficiently large numbers to be of use in checking the weevils.

8. Insecticides. Two insecticides were received for trial, (1) Orr's Wood Preservative against termites and (2) Incosopol, a preparation from cotton seed oil, manufactured by the Indian Cotton Oil Company of Navsari, Bombay Presidency, for trial against plant lice and such other insects. The trials have been undertaken.

Bagrada picta appeared in an experimental plot of mustard and spraying with Fishoil Resin soap at a strength of 1 lb. in 4 gallons of water checked it entirely, killing even the adults.

9. Lantana work. This work was taken up on instructions from Government and has for its object the collection of information regarding the occurrence within

the Indian Empire of any insects which may be utilized as efficient checks on the growth of *Lantana*. With this object Mr. Y. Ramachandra Rao, Entomological Assistant in Madras, has been placed on special deputation under the Imperial Entomologist, for a period of two years in the first instance, from 16th November, 1916. He has commenced work in Southern India and has made a study of the insects affecting *Lantana* in Madras, Mysore and Coorg. A large number of insects has been found to occur on *Lantana* but most of these appear to be either casuals, not confined to *Lantana* but usually very polyphagous in their habits, or of no importance as checks on *Lantana*. The insects found hitherto and which appear likely to be of use are (1) *Platyptilia pusillidactyla*, Wlk., (2) a Eucosmid moth, apparently a novelty, and (3) a Cecidomyiad fly; of these, *Platyptilia pusillidactyla*, which was one of the insects imported from Mexico into Hawaii to check *Lantana*, is already widely distributed in India and Burma, and of the other two insects further investigation is required regarding their actual value and distribution.

V. Bees, Lac and Silk.

1. Bees. The experiments with the Indian Bee (*Apis indica*) were continued. There is, however, nothing of particular interest to record.

2. Lac. Emergence of Lac larvæ took place at Pusa on 20th September, 1916, and 23rd June, 1917. Numerous inquiries for Brood-lac, etc., were dealt with during the year. No student attended the short courses in Lac-culture.

3. Silk. Three students completed short courses in Eri and Mulberry silk and six remained under training; of these nine men one was deputed by the Indore State and one by Travancore, one each came from Bombay, Mysore, Bengal, and the United Provinces and three came from Bihar.

Mr. Lefroy, the Imperial Silk Specialist, Mr. McNamara, the Director of Sericulture, Kashmir State, and Mr. Gopal Krishnan, of the Mysore Sericulture Depart-

ment, visited the Silk House. The members of the Industrial Commission, who visited the Silk House, were much interested in the reeling and weaving work.

Mulberry silkworm eggs were sent to the Travancore, Mysore, Banganapalle, Bhopal, Rewah, Indore, Gwalior, Poonch (Kashmir) and Jodhpur States, to the Deputy Director of Agriculture and Land Records, Coorg, to the different silk centres of the Salvation Army and to the Tiflis Sericultural Station (Caucasus). Eri eggs were supplied to one hundred applicants and mulberry eggs to ninety-one applicants. Eri and Mulberry seed cocoons were sent to the Director, Entomological Section, Cairo (Egypt). Mulberry cuttings and seeds were supplied to the Director of Agriculture, Burma, and to the Agricultural Officer, North-West Frontier Province, respectively. Castor and Mulberry seeds, Mulberry cuttings and samples of different kinds of silk were distributed to many inquirers. Instructions for rearing, reeling, dyeing, bleaching and spinning were given by correspondence. Univoltine Mulberry silkworm eggs were sent to Shillong, Muktesar and Guindy (Madras) for cold storage and gave satisfactory results on rearing in November and March.

We at last seem to have succeeded in establishing a multivoltine hybrid race, the yield of silk of which is about 75 per cent. more than the multivoltine races generally reared in Bengal. All the eggs of the last three generations of this race have hatched like the eggs of multivoltine races and it is hoped that they will continue to do so in future. The time has perhaps come to introduce the race in the various rearing centres.

About 19 different varieties of Mulberry trees have been planted and consignments of leaves, flowers and fruits of some of them have been sent for identification to the Economic Botanist of the Botanical Survey of India, Calcutta. Silk Exhibits were sent to the Bengal Art Exhibition, Darjiling, the Mysore Dasara Exhibition, and to the Burma Exhibition held in Rangoon in connection with the Viceroy's visit. A Silver Medal was awarded from the Darjiling Exhibition and honourable mention was made

by the Mysore Dasara Exhibition Committee. Two reelers were sent to the Burma Exhibition to demonstrate the Bengal method of reeling.

Silk pieces to the value of Rs. 644 were sold and the proceeds credited to Government.

An improved Silk Twisting Machine has been made recently, on which about half-a-pound of Mulberry, Muga or Tasar reeled silk can be twisted by a boy or girl in eight hours. A twisting machine has been lent to the Deputy Director of Agriculture, Assam. Mulberry, Eri, Muga and Tasar show cases were supplied to the Director of Sericulture, Kashmir State, and to the Agricultural Inspector, Muzafferpur. Some very fine silk guts were especially made for Galvanometer magnet at the request of the Officer-in-Charge, No. 18 Party (Magnetic), Survey of India.

Various experiments to improve the Mulberry silkworm races were carried on, and the Second Report on these Experiments is now in the press. Bulletin No. 39 on Mulberry Silkworm rearing, the second edition of which has come out, has become very popular.

VI. Illustrations.

Coloured plates illustrating the life-histories of the following insects were prepared during the year, *viz*:—*Xylotrechus quadripes*, *Laspeyresia pseudonectis*, *Ancylolomia chrysographella*, *Scirpophaga xanthogastrella* (*auriflua*), *Argina cribraria* and *Amsacta moorei sara*. Line-drawings of about sixty insects, showing life-histories in more or less detail, and about one hundred drawings of other insects, were also prepared.

The issue of coloured plates and lantern slides has been continued, thirty new plates (including eleven of mosquitos) being printed and issued during the year.

VII. Miscellaneous.

Correspondence. A total of 110 parcels of specimens, mostly of crop-pests, was received during the year for identification and advice, whilst 1,010 letters were received and 1,312 issued, but all these numbers are exclusive of a

large amount of routine correspondence, which every year becomes more and more onerous and takes up time which should be devoted to more productive work.

VIII. Insect Survey.

Steady progress has been made in additions to, and arrangement of, the collection. The whole of the collection of Lepidoptera (including the Micro-lepidoptera) has been overhauled, rearranged and placed in one series, so that all the information on any species or group is now available in one place. The work of rearranging the Coleoptera has been practically finished, and the same has been done in the case of the Orthoptera and part of Rhynchota. The identification of the collection of Diptera was undertaken by Mr. Brunetti during the year and is now in progress.

The collections continue in good order, but the difficulty of maintaining them, in boxes in open racks in a climate such as that of Pusa, is very great.

The following collections have been sent out to Specialists in the groups named and our thanks are due to them for the help afforded :—

(*i*) Carabidæ to Mr. H. L. Andrewes. Partly named and returned.

(*ii*) Curculionidæ to Dr. G. A. K. Marshall. Partly named and returned.

(*iii*) Anthribidæ to Dr. K. Jordan. Not yet returned.

(*iv*) Rutelidæ to Mr. G. J. Arrow. Named and returned.

(*v*) Melolonthidæ to Mr. G. J. Arrow. Partly named and returned.

(*vi*) Cerambycidæ to Mr. C. J. Gahan. Not yet returned.

(*vii*) Histeridæ to Mr. G. Lewis. Not yet returned.

(*viii*) Sphegidæ to Mr. Rowland E. Turner. Returned named.

(*ix*) Formicidæ to Dr. C. M. Wheeler. Returned named.

(*x*) The Apidæ named by the late Mr. G. Meade-Waldo have been returned.

(*xi*) Braconid parasites of *Earias* to Professor C. T. Brues. Not yet returned.

(*xii*) Tenthredinidæ to Mr. Rohwer. Returned named.

(*xiii*) *Dacus oleæ* and its parasite to Professor Silvestri. Named and descriptions published.

(*xiv*) Tubificid worms infesting paddy to Lieutenant-Colonel J. Stephenson. Examined and information communicated.

(*xv*) An Ichneumonid reared from cell of *Pseudagenia blanda* to Mr. C. Morley. Named and will be returned.

(*xvi*) Hispinæ and Cassidinæ to Mr. S. Maulik. Not yet named and returned.

(*xvii*) Micro-Lepidoptera to Mr. E. Meyrick, F.R.S. Named and returned.

Various collections of Indian insects have been received and named and returned as far as possible. These included collections sent by the Provincial Agricultural Departments and by numerous correspondents.

IX. Entomological Meeting.

A Second Meeting of the Entomological Staffs of Pusa and the Agricultural Departments of the Provinces and Native States was held at Pusa from 5th to 12th February, 1917, and was attended by twenty-five members and two visitors. All Indian crops and their insect pests, and the life-histories and methods of control of these latter, were gone over and discussed, and the Meeting proved very valuable to all who attended it. A full report of the Meeting has been prepared and is now in the press.

X. Programme of work for 1917-18.

Major.

This will follow generally on the lines of work of the current year and will include general investigations of crop

pests and especially of the pests of sugarcane, rice and cotton, of fruit-trees, of stored grain, and of insects affecting *Lantana.*

Minor.

Results in various lines of work require to be written up and published as far as possible. Work and experiments in silk, lac, and bee-keeping will be continued, and new insecticides and insecticidal methods tested as occasion arises. Systematic work on Indian insects will be carried out with our own resources and the help of specialist correspondents. Advice and assistance will be given as far as possible to Provincial Departments and to all inquirers on entomological subjects.

XI. Publications.

The following publications, either written by the Pusa Staff or based on material sent from Pusa, have been issued during the year* :—

Arrow, G. J. . . The Khapra Beetle (*Trogoderma khapra*, n. sp.), an Indian Grain-pest. (*Ann. Mag. Nat. Hist.* (8), XIX, 481-482).

Arrow, G. J. . . Coleoptera Lamellicornia, Part II; Rutelinæ, Desmonycinæ and Euchirinæ. (*Fauna of British India Series.* Pages xiii + 387, 5 tabs, 77 text-figs.)

Bezzi, M. . . On the Fruitflies of the genus *Dacus* (s.l.) occurring in India, Burma and Ceylon. (*Bull. Entl. Res.*, VII, 99-121.)

Brunetti, E. . . Diptera of the Simla District. (*Rec. Ind. Mus.*, XIII, 59-101.)

Crawford, J. C. . Nine new species of Hymenoptera. (*Insec. Inscit. Menstruus*, IV, 101-107.) [*Tetrastichus pyrillæ* and *Ooencyrtus pyrillæ*, n. spp.]

Fletcher, T. Bainbrigge. Tiger Beetle Borer of Coffee. (*Planters' Chronicle*, XII, 14-16.)

*The list includes papers in the press which are due to appear before the issue of this report.

Fletcher, T. Bainbrigge. Report on Agricultural Entomology, 1915-16. (*Board of Scientific Advice Annual Report.*)

Holmgren Karin and Nils. Report on a Collection of Termites from India, Translated by T. Bainbrigge Fletcher. (*Mem., Dept. of Agri., India, Ent., Series*, Vol. V, No. 3.)

Marshall, G. A. K. On new species of Indian Curculionidæ, Part III, (*Ann. Mag. Nat. Hist.* (8), XIX, 188-198.)

Marshall, G. A. K. Rhynchophora—Curculionidæ, Part I. (*Fauna of British India Series.* Pages xi+367, 108 figs.)

Marshall, G. A. K. On new weevils of the genus *Mecysmoderes* from India. (*Ann. Mag. Nat. Hist.* (8), XIX, 395-404.)

Meyrick, E. . . Exotic Microlepidoptera, Vol. I, Part 20, Vol. II, Part 1.

Misra, C. S. . . Indian Sugarcane Leaf-hopper (*Pyrilla aberrans*, Kirby). (*Mem., Dept. of Agri., India, Ent. Series*, Vol. V. No. 2.)

Silvestri, F. . . Sulle specie di Trypaneidæ del genere *Carpomyia* dannose ai frutti di *Zizyphus*. (*Boll. Lab. Zool. Portici* XI, 170-182, figs.)

Silvestri, F. . . Descrizione di alcuni Imenotteri Braconidi parassiti di Ditteri Tripaneidi nell India. (*l.c.*, 160-169, figs.)

Silvestri, F. . . Prima notizia sulla presenza della mosca delle olive e di un parassita di essa in India. (*Reale Accad. dei Lincei* (5), XXV, 424-427, figs).

Turner, R. E. . . Notes on the Wasps of the genus *Pison* and some allied genera. (*Proc. Zool. Soc.*, 1916, pp. 591-629.)

Turner, R. E. . . On a Collection of Sphecoidea sent by the Agricultural Research Institute, Pusa, Bihar. (*Mem., Dept. of Agri., India, Ent. Series*, Vol. V, No. 4.)

REPORT OF THE IMPERIAL PATHOLOGICAL ENTOMOLOGIST.

(T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S.)

I. Charge and Establishment.

I was in charge of this section in addition to my own duties as Imperial Entomologist, during the whole year (1st July, 1916, to 30th June, 1917).

Messrs. Patel and Sharma, Entomological Assistants, were absent from 5th July to 5th November, 1916, on military duty, being employed on Fly Control work in Mesopotamia.

Mr. P. G. Patel was absent on privilege leave from 10th March to 5th April, 1917, and Mr. S. K. Sen from 12th October to 23rd December, 1916.

Tours. Messrs. Sharma and Sen visited Calcutta in December and April respectively, to take down specimens of Diptera to be named up by Mr. Brunetti, who has been employed during the year on the identification of the Pusa collection of this Order.

II. Work done. Disease-carrying insects.

Saprozoic Flies.

The observations, commenced three years ago by Messrs. Howlett and Patel, on the attraction exercised on flesh flies and other insects by dead animal matter in different stages of putrefaction have been continued and the observations up to date are partially summarized below.

Pycnosoma flaviceps. Flies of this species are most strongly attracted to putrefying meat or dead animals. The life-cycle from egg to egg is about 38 days. Like *Sarcophaga* this fly is capable of infecting meat by dropping its eggs through wire gauze. These flies have lately

been noticed to be strongly attracted to over-ripe cut mango fruit. A plant (probably a *Justicia*), when in flower, attracts flies of this species (and many other Diptera) in large numbers. Maggots extracted from human nostrils, from tumours, and from the foot of a cow suffering from foot-and-mouth disease were bred out as flies which are apparently *Pycnosoma flaviceps*.

A Calliphorine Muscid, probably a species of *Chrysomyia*, is always observed to follow *Pycnosoma*. It is seen attracted to putrefying meat in the same way as *Pycnosoma*. The chief points of interest of this species are :—(*i*) the form and predaceous habits of the larvæ, (*ii*) females of this species are in the habit of producing progeny of one sex only.

The larvæ of this species are hard-bodied and spiniferous, each spine being finger-shaped, the apex again split up into hook-like bristles. They are predaceous in habit especially at times of scarcity, which is not uncommon as the number of larvæ found upon a dead animal or piece of meat is generally in excess of their food-supply. Experiments conducted on the predaceous habits of these larvæ show that they prefer *Sarcophaga* and *Pycnosoma* to other larvæ, as the larvæ of both these genera are fleshy, smooth, and apparently harmless. Phorid larvæ, excepting one spiniferous species, are also liable to be attacked and, in the absence of any such larvæ, the *Chrysomyia* larvæ fight amongst themselves and devour each other.

The habit of producing progeny of only one sex is curious. Instances of producing progeny of one sex amongst insects, such as bees and Aphids, are well known but such are usually the effect of Agamogenesis, *i.e.*, a female without sexual intercourse produces progeny. Several experiments were carried out to see if Agamogenesis is common amongst these flies. Batches of bred virgin females were confined on several occasions with food, humidity, and all other necessary conditions in a fly cage to see if they could produce progeny without having any intercourse with males. Side by side both males and females were also confined in a

separate cage as controls. Only in the control cage did the flies begin to breed. No females without intercourse of males were noticed to lay viable eggs; they laid eggs but these were never seen to hatch out. Data regarding the life duration from egg to egg, the longevity of a virgin fly, as also of a fertilized mother-fly, etc., have been observed. Under the same climatic conditions in captivity one female will produce only males whilst another will produce females, which seems to show that climatic conditions do not take any part in the causation of sex. Perhaps age and food have something to do regarding the causation of sex in this insect. Experiments on this point would certainly repay further study.

Sarcophaga ruficollis. Members of the genus *Sarcophaga* are known carrion haunters. They extrude living larvæ instead of eggs and are amongst the first visitors to exposed meat or dead animals. These flies are common about human fæces, undigested cattle dung, and carrion. They feed both upon sugary and nitrogenous substances. They breed readily in flesh and human fæces. The larval period as noticed is 10 days but the pupa takes double the larval duration. Maggots which were extracted from a tumour of a patient in Pusa Hospital proved to belong to a species of *Sarcophaga.*

Lucilia sp. A species of *Lucilia*, having a white face, dark antennæ and dark prothoracic stigmata, was seen attracted to exposed meat and dead animals at almost all seasons excepting during very severely cold days of winter. The life-history from egg to egg occupies 25 days. One fly was noticed to breed twice in her lifetime. The adults were kept alive for a period of six to seven weeks.

Lucilia sp. No. 2. This species differs from the above in having golden yellow antennæ. Freshly emerged female flies when kept in a fly cage with males and all necessaries of life refused to breed. Larvæ pupate by instalments.

Piophila casei (Sepsidæ). These little flies visit meat especially when the fatty tissues get advanced in fermenta-

tion. They breed in such material. The life-cycle period is about 11 days. The larvæ are capable of jumping, and this is a characteristic trait in them. They are parasitized by a small Hymenopterous parasite. This parasite is not confined to this species but will attack any flesh fly pupæ, preferably those of Phorids.

Aphiochœta ferruginea (Phoridæ). Flies of this species are attracted both to fresh and fermenting meat. They suck fresh meat and oviposit in the rotten meat. The mature larvæ, contrary to the habit of young larvæ, leave the place of feeding and go to an open place to pupate. The larva matures within ten days but the pupa takes the unusually long period of about four weeks.

Another species of Phoridæ, probably of the genus *Ecitomyia*, frequents decomposing meat or dead animal. Females of this species have much reduced wings. The males are darker and have well-developed wings. The larvæ are spiniferous, compressed dorso-ventrally, with a pair of conspicuous slightly protruded reddish hind spiracles, head tapering with reddish yellow tinge on the cephalic region. The pupal period was noted to be 15 days. The larva pupates where it has fed.

A large species of Phorid of the genus *Phora* was seen attracted very often to putrefying meat. Several flies caught while in the act of oviposition were noticed to be infested with an acarine mite. The infection was confined only to the abdominal segments. The larvæ are spiniferous, the thoracic segments with irregular reddish spots; they take from seven to eight days to become full grown.

Flies of a species of *Ophyra* (Anthomyiadæ) were very often noticed specially when the tin containing meat was exposed under shady places. These flies are conspicuous by their dull metallic colour. They frequent such places more for food than for oviposition. On one occasion maggots of these flies were found and reared in a vessel containing very old meat mixed with loose earth. They do not seem to breed in fresh or putrefying meat.

A species of *Drosophila* was bred out from very old flesh which had lost all smell of decomposition. The life-cycle was found to be nine days from egg to adult. The pupæ remained firmly fixed at the place of their breeding.

Besides the flies mentioned above, several species of Coleoptera are commonly attracted to putrefying flesh.

Necrobia rufipes (Cleridæ), a small metallic dark green beetle, not infrequently visits dead carcases and old meat. They have been found to exhibit a preference for eating dead maggots and animal matter. They breed freely in old meat. The larvæ are soft, elongated and slightly dilated posteriorly; the head portion is a little narrower, flat, and brownish. They were observed to eat dead or damaged flesh fly pupæ in confinement.

Four species of Histeridæ were found to be readily attracted to putrefying meat. The adult insects were observed to prey upon flesh fly maggots of any species but preferably of big species. None of these beetles have as yet been found breeding in fermenting meat or dead animal matter.

Dermestes vulpinus (Dermestidæ) visits decomposing meat or dead animals, perhaps with the object of breeding. A single beetle was seen laying a dozen eggs. The larvæ are elongated with leathery plates on the dorsum of the body which is clothed with long hairs. A single larva moults more than five times. The adult beetles counterfeit death on being alarmed. The larvæ feed upon animal matter but were not found to prey upon any living flesh fly maggots.

Adult flies of *Musca nebulo, M. angustifrons, M. nigrithorax, Ulidia œnea* and of a small species of Borboridæ were trapped whilst attempting to feed on exposed meat, but none of them were ever seen to breed in such material.

Species of *Calliphorinæ* and *Sarcophaga* breeding in flesh are subject to the attack of three kinds of parasites two of which belong to the family Chalcididæ. Of these one species with reddish hind legs attacks flesh fly maggots

in their larval stage. It was observed to hibernate in the larval state inside the flesh fly pupæ during the cold of winter. The other species is conspicuous by its widely opened mouth; this species attacks flesh fly pupæ as also full-grown larvæ. The third parasite is very minute and confines its attention chiefly to the maggots of small species of flesh flies, such as Phorids, Sepsids, etc. It has also been bred out from the pupæ of *Sarcophaga* and *Pycnosoma*. Even the parasitized pupæ of *Sarcophaga* and the *Calliphorinæ* were observed to be attacked by this small parasite, which apparently acts as a hyperparasite to the true Chalcidid parasites of *Sarcophaga* and *Calliphorinæ*.

Tabanidæ.

Observations regarding the gregarious egg-laying habit of *Tabanus nemocallosus* were continued.

Tabanidæ in general are in the habit of depositing their eggs in the vicinity of water but a great deal of difference in the selection of positions has been marked amongst these flies. Small Tabanids such as *Tabanus bicallosus*, *T. virgo*, two species of *Hæmatopota*, and *Chrysops stimulans*, are in the habit of ovipositing on the leaves of aquatic plants such as *Polygonum glabrum* and *Phragmites kurka*, which grow in shallow water. The time of egg-laying differs in different species; for instance, *Chrysops stimulans* was observed on almost all occasions to oviposit between noon and 2 P.M.; *Tabanus bicallosus* will lay throughout the day but preferably between 9 and 10 A.M.; *Hæmatopota* spp. were seen to oviposit mostly during morning and evening hours but never during the strong heat of the day.

Eggs of all these small Tabanids are always arranged in a single layer and they are free from egg parasites.

Amongst the larger species, *Tabanus albimedius* does not seem to be particular about situation; it has been observed to lay eggs on any aquatic plants grown either in deep or shallow water or mud. Any small accumulation of water either casual or permanent, will attract these flies

to lay their eggs. Even a watery appearance, such as is produced by a window-pane or a cemented floor, has been noticed to mislead these flies into laying their eggs. Leaves of big trees hanging over water at a distance from 3 to 5 yards, logs of wood, etc., have also been utilized by these flies for oviposition. *Tabanus striatus* and *T. hilaris* have more or less the same habits.

The eggs of the larger species of *Tabanus* found at Pusa are always laid in a mass. These eggmasses are cemented by gluey substances by the mother fly, apparently to protect them from enemies. Eggs of one species, probably *Tabanus speciosus*, are covered up with some chalky substance by the mother fly. All these eggmasses are subject to the attack of Chalcidid parasites.

The flies of *Tabanus nemocallosus* are moderate in size and their eggs are arranged in a mass, which is apparently uncemented and without any definite shape. Eggs of other large species are arranged more or less in a definite pattern of their own.

Tabanus nemocallosus requires a special situation to lay its eggs. A plant, *Phragmites kurka*, which is conspicuously taller than its neighbours and whose top portion droops downwards over deep water is almost invariably selected by this fly. Another plant, *Lantana aculeata*, having the same posture as described above, was seen to be utilized by these flies in June, 1917. As many as 19 flies were counted engaged in oviposition and more than 200 eggmasses, old and fresh, were seen deposited on a single plant of *Phragmites kurka* in June, 1917.

Some fresh eggmasses of *Tabanus nemocallosus* were crushed and the leaves of a plant of *Phragmites kurka* were smeared with the juice to see if these flies are attracted to such smell for oviposition but no fly seemed to take notice of it. The same experiment was repeated with the leaves of *Lantana aculeata* but met with a negative result.

Under laboratory conditions the emerging larvæ exhibited the gregarious habit as usual. A very few of them

were observed to wriggle to come up to the water surface when kept in a big aquarium; the majority of them lived in separate batches of masses at the bottom and never tried to wriggle up. They were observed to live under such conditions from 16th June to 26th June, 1917, but gradually began to decompose after this. A few survived under submerged conditions till 29th June, 1917, and almost all were found dead on 2nd July, 1917. Even when the water was rendered more or less air-free by boiling, these larvæ showed considerable resistance to death from drowning. This observation may throw a little further light on the possibility of the utilization of dissolved air by aquatic larvæ.

Freshly laid eggs, when submerged in water, failed to hatch out, but they could stand submergence for 72 hours.

Fourteen flies, both males and females, emerged in July, 1917, from the lot of larvæ of *T. nemocallosus* taken during the month of December, 1916.

Freshly emerged flies of this species would not suck blood for some time (under laboratory conditions). They are capable of resisting starvation for a full period of five days if they are kept in humid surroundings. The starved flies when allowed to bite a goat readily filled themselves with blood within five minutes. They show a marked tendency to drink water in captivity. Newly emerged flies when they have once acquired a habit of sucking sugary food are always found to be very reluctant to suck blood afterwards.

T. nemocallosus in all probability has one brood in a year. Larvæ of this species collected during December, 1916, were found about as long as a full-grown one. It is our common experience that Tabanidæ disappear during winter. No fly of this species nor of any other Tabanidæ was bred during cold season. Tabanidæ in general hibernate during the winter in their larval stage. So the larvæ of *T. nemocallosus* taken during December must be the outcome of eggs deposited in September or October. Some larvæ from the above batch have still to pupate. From these data the

maximum larval period seems to be 9 to 10 months. As the rate of development amongst these larvæ is very irregular we very often come across flies of this species at most times of the year except the winter.

The eggs of *T. nemocallosus* were found attacked by a Chalcidid parasite which is conspicuously smaller than the parasites of the larger species of *Tabanus*. An apparently similar parasite was bred out from the eggs of a species of Acalyptrate fly which were collected in the vicinity of Tabanid eggs.

Culicoides sp.

Several flies of a species of *Culicoides* were bred out from the green vegetable substances (algæ) taken from near the edges of a well reservoir. The larvæ as also adults differ from *Culicoides kiefferi*. The larvæ of the Pusa *Culicoides* are in habit of remaining half buried inside the green vegetable substance. Many larvæ were seen congregated in this way at one spot for a considerable time. Occasionally they come up to the water surface and move here and there with a characteristic vibratile motion. They often rest on the edges of a vessel containing water by keeping their heads or bodies exposed. Moulting and pupation take place under water, the pupa remaining floating on the water surface. Those which are not able to float apparently do not succeed in hatching out. A full-grown larva measures a little more than 3 mm. in length and differs from the larvæ of *Culicoides kiefferi* in having a pair of very minute hairs one on each side of the prothoracic segments. The same sort of hairs were seen on meso- and meta-thoracic segments of several larvæ. The pupa measures about half the length of the full-grown larva. The last segment of the pupa terminates in two tooth-like spines which are longer than those on the rest of the pupal body. The breathing trumpets are dark in colour, especially at the apical portion. Their stalks are lighter and thin and are supplied with three very small dark protuberances. The pupa takes about 60 hours to hatch out. The freshly emerged flies have

their abdomen of a greenish colour which gradually turns darker.

Dung-Flies.

Observations were made on the flies found breeding in the dung of various animals at Pusa and the following species were bred out :—

Breeding material	Species emerged	Remarks
Cow dung . .	*Philæmatomyia insignis.*	
	Bdellolarynx sanguinolentus.	
	Lyperosia minuta.	
	Sepsid sp	
	Anthomyiadæ, 4 spp.	
	Musca corvina.	Viviparous (flies extrude larvæ instead of eggs).
	Musca sp.	
	Pyrellia sp.	Full-grown larvæ of this species are bluish green. Puparium reddish.
Calf dung . .	*Sarcophaga* sp.	
	Phorid sp.	
	M. angustifrons.	
	Fannia sp.	Flies of this were bred out during last year.
Sheep dung . .	*Musca* sp. (*domestica* type).	A 4-striped *Musca* but according to Awati it is other than *domestica* or *nebulo.*
	Ulidia ænea.	
	Borborid sp.	
Horse dung . .	*Musca nebulo.*	
	Borborid sp.	
Litter from old manure heap	*Ulidia ænea.*	The smell of the breeding material was something like vinegar.

Mosquitos.

Investigations were made in the viability of *Stegomyia* eggs obtained in a desiccated condition in rubbish in hol-

lows of trees. It was found that, to secure viability, these eggs require to be kept under moist conditions for some time previous to desiccation, to mature their contents; this condition fulfilled, they can resist desiccation for over six months, and it is evident that at Pusa *Stegomyia scutellaris* hibernates in the egg stage and so remains until the hollows in trees are filled with rain-water towards the middle of the year.

At Pusa only *Stegomyia scutellaris* and *Aedes thomsoni* have been found capable of resisting a long period of desiccation. In the following species, which also breed mainly in hollows in trees under natural conditions, the capacity to withstand desiccation is much less, *viz.*, *Stegomyia w-album*, *Ochlerotatus gubernatoris*, *Armigeres obturbans*, and *Cyathomyia brevipalpis*.

Armigeres magnus was observed for the first time this year at Pusa and its life-history was worked out. It is rather a rare mosquito for this locality and appears in the early portion of the rainy season, breeding in bamboo stumps, and on very rare occasions in the hollows of trees as well. Its bite is rather severe. It is larvivorous in the larval stage and is the third known larvivorous species available in this locality, the other two being *Culex concolor* and *Armigeres obturbans*. Though it is not so highly larvivorous as *Culex concolor*, it is almost equal in this respect to *Armigeres obturbans*. It lays its eggs in small clusters loosely stuck to each other. They are bigger than *Stegomyia* eggs. The full-grown larvæ have comparatively large gills and their wriggling motion resembles very much that of *Armigeres obturbans*.

Some observations have been made on the bionomics of *Cyathomyia brevipalpis*, a sylvan species, which does not suck human blood and which has the habit of congregating in very large numbers in undisturbed, dark, dry places such as hollows in trees. Its eggs are laid in clusters and it breeds in hollows of trees as well as in stumps of cut bamboos. Its larval siphon is comparatively very large.

Cut pieces of bamboo, which are filled with water and placed out at Pusa as breeding-traps for some mosquitos, attract most of the mosquitos which breed in hollows in trees. The following species have been found breeding in these bamboos and reared, *viz.*, *Stegomyia scutellaris*, *S. w-album*, *Cyathomyia brevipalpis*, *Armigeres magnus* and *A. obturbans;* of these *S. scutellaris* is attracted in the largest numbers and, next to that, *S. w-album*, the other species being found only occasionally in such situations.

The Mosquito Campaign on the Pusa Estate was continued on the lines noted in last year's report. Considerable success was attained, the reduction of *Stegomyia* spp. during the rains being particularly marked.

Experiments on the rôle of blood in the development of the eggs of mosquitos were continued and the results published in the *Indian Journal of Medical Research.*

Eleven coloured plates, showing life-histories of mosquitos, were issued during the year.

III. Publications.

Sen, S. K. A preliminary note on the rôle of blood in ovulation in the Culicidæ (*Indian Journal of Medical Research*, April 1917).

IV. Programme of work for 1917-18.

Work will be continued on the life-histories and control of the insects and allied organisms which are concerned in the transmission of disease to man and animals in India.

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST.

(C. M. Hutchinson, B.A.)

I. Administration and Tours.

Charge. I held charge of the Section throughout the year.

Establishment. Mr. Umrao Bahadur Mathur, Laboratory Assistant, was on privilege leave for twelve days from 10th to 21st April, 1917.

Tours. The following tours were made by me during the year under report :—

July, 1916. To Motipur factory in connection with indigo experiments.

September and October, 1916. To Kashmir to investigate conditions of silkworm seed selection in Kashmir and to Shillong to enquire into the condition of silkworm rearing in Shillong with special reference to incidence of pebrine.

November, 1916. To Berhampore and Ramnagger in connection with pebrine experiment and to Muzaffarpur to give evidence before the Indian Industrial Commission.

January, 1917. To Muzaffarpur, Dalsing-Serai, Pemberanda, Motipur and Peeprah to obtain information as to experimental indigo vats.

February, 1917. To Muzaffarpur to address the Bihar Planters' Association in connection with indigo manufacture and to Jallaha in the Champaran District to obtain information as to the design of indigo vats.

March, 1917. In the Champaran District in connection with the indigo factory enquiry.

April, 1917. To Muzaffarpur, Mohammadpur, and Dholi in connection with the experimental indigo factory.

May, 1917. To Muzaffarpur, Seraiah, Motipur, Dooriah, Belsund and Tabca in connection with the indigo experiments.

June, 1917. To Muktapur, Muzaffarpur, Motipur and Bara in connection with the indigo experiments.

Mr. Harihar Prasad, one of the Fieldmen attached to the Entomological Section, whose services were kindly lent to this Section by the Imperial Entomologist in connection with the pebrine disease experiment, was sent to Berhampore silk nurseries to demonstrate the improved method of examination of moths for pebrine as devised in this laboratory.

II. Training.

Mr. S. N. Bose, Bacteriological Assistant to the Agricultural Chemist to the Government of Bengal, is under training in this laboratory.

III. Soil Bacteriology.

Soil fertility in its relation to bacterial activities. This included further work upon nitrification with special reference to the interference with this process resulting from—

(1) The absence of the necessary specific organisms in some soils.

(2) The inhibiting action of toxins produced in soils under semi-anaerobic conditions.

The apparently complete absence of nitrifying organisms in certain soils was certified and confirmed by continued examination of further samples in which nitrification of added organic matter was secured only after inoculation with nitrifying organisms derived from other soils. The principal feature of such soils probably responsible for the absence of nitrifying organisms, is the bad texture making good tilth difficult to obtain; added to this is a deficiency of lime. Both these objectionable features

would have to be modified by cultivation, growth of green manures, and addition of lime, before inoculation of the soils could be attended with success. Defective nitrification was found especially marked in certain soils from Ranchi.

Soil I did not form any nitrate at all either with ammonium sulphate or cake, even on addition of lime. Inoculation with Pusa soil produced nitrification of 75 per cent. of ammonium sulphate and 90 per cent. of cake nitrogen in six weeks' time.

Soil II. This soil failed to produce any nitrate from ammonium sulphate in six weeks, but nitrified 50 per cent. of added cake nitrogen in this time, probably owing to the introduction of nitrifiers with the cake. Inoculation with Pusa soil resulted in complete nitrification of the ammonium sulphate in six weeks and of the cake in four weeks. In this soil addition of lime increased the rate of nitrification.

Soil III. This soil nitrified 25 per cent. of added ammonium sulphate nitrogen in four weeks; inoculation produced complete nitrification (100 per cent.) in the same time.

Soil IV. 15 per cent. ammonium sulphate was nitrified in six weeks; inoculation produced complete nitrification in the same period.

The addition of lime alone produced increased nitrification in the soils II, III and IV, but had no effect on soil I, nor was the addition of lime only in any case as efficacious as inoculation.

Barley and maize germinated and grew well in these soils for one week, after which growth stopped, the seedlings lost colour and all died after three weeks.

The effect of toxins produced by bacterial action upon nitrification was further studied. It was found that soil plus organic matter incubated under semi-anaerobic conditions gave a water extract which considerably lowered the rate of nitrification when added to another soil. This extract, on being made alkaline with caustic soda, gave a white precipitate, containing more than 5 per cent.

nitrogen; this substance has a decided retarding effect upon nitrification. Acidification of the filtrate from the above yielded a white crystalline substance soluble in dilute acids and containing rather more than 4 per cent. of nitrogen: this substance was found to increase the rate of nitrification in Omelianski solution.

Phosphate requirements of soil bacteria and their relation to plant growth. A series of experiments dealing with this subject was initiated; the results so far obtained do not suggest that solubilization of tricalcic soil phosphates by bacterial action is sufficient in amount to produce a surplus supply of soluble phosphate for the direct use of higher plants, but rather that the bacteria dissolve only sufficient for their own requirements. It seems clear, however, that such important fertilizing bacterial actions as nitrification depend for their occurrence in any useful degree upon proper supplies of phosphatic bacterial food, and it is also clear that carbonic acid resulting from bacterial action in the soil will in course of time solubilize sensible quantities of mineral phosphate.

Biological analysis of soils. Numerous samples of soil were analysed by the method elaborated in this laboratory; much useful information has been obtained in this way as to the close relation between bacterial activity and soil fertility. Application of the method to *reh* soils in the Punjab was found of great value by the Agricultural Chemist to the Government of the Punjab, whose assistant had been trained in its use in this laboratory. It is to be hoped that the untimely death of Mr. Barnes, whose criticism and advice in connection with the chemical methods involved were of great value to me, will not prevent a continuation of this enquiry.

Familiarization with the use of the method forms a useful preliminary training for students in this Section.

Green-manuring. Field experiments on the modified method of green-manuring devised in this laboratory, have been continued in collaboration with the Imperial Agriculturist on the farm, and also in the bacteriological area,

where a very large crop of Java indigo was obtained by its use; this crop was not only heavier than those obtained on control plots manured with cake, but on analysis by the Indigo Research Chemist was found to contain a higher percentage of indican.

Leguminous root nodule organisms. Experimental work upon cross inoculation with different strains of *Ps. radicicola* was carried out by Mr. Joshi, First Assistant in this Section. It was found that in several instances very substantial increase in growth both of roots and of the whole plant resulted from inoculation, although characterized by complete absence of nodule formation. This was especially the case when cultures from one species of plant were used to inoculate a different species; it is suggested that this forms a case of incompletely developed symbiotic relationship due either to greater resistance to invasion on the part of the host plant, to less parasitic ability on the part of the invading organism, or merely to a lower degree either of stimulation by the parasite or of reaction to stimulus by the plant. The results of this enquiry will be published shortly.

Plant diseases. Bacterial diseases of wheat, poppy, and citrus trees were under investigation during the year. A Memoir on the first of these is now in the press.

Poppy. Blackening and slimy decay of the stem and leaves of the opium poppy and other varieties was found to be due to bacterial rot; a description of the disease and of the causative organism is in hand for publication.

Citrus canker. This disease has been known in India for several years; some forms of it were found to be due to the action of *Ps. Citri* well known as the cause of this disease in Africa and America where it has caused very widespread and serious damage. Further investigation will be made during the next year.

IV. Indigo.

Work on this subject has been continued in collaboration with the Indigo Research Chemist and has afforded

further confirmation of the importance of bacterial action in indigo manufacture.

It has been shown that the failure in factory practice to obtain nearer approximation to the theoretic yield of indigo from the plant is due to several factors of which the following have now been found to be of importance :—

(1) *Destruction of indican in the leaf during fermentation or steeping.* This appears to be due to several causes all preventing the desirable change of indican by hydrolysis into indoxyl. These probably include the action of plant enzymes and bacteria other than those producing indoxyl from indican. With this source of loss may be associated

(2) *Incomplete extraction of the indican,* as although no residual indican may be found remaining in the plant after steeping, yet investigation has shown the very strong probability that its absence is due not to removal into solution in the steeping water but to actual destruction or decomposition *in situ.* This destruction appears to be due partly to enzymic and partly to bacterial activity other than that resulting in production of indoxyl.

Control of the fermentation taking place in the steeping vats must therefore take the form of introducing conditions which will minimize such losses, probably on the following lines :—

(1) Promote rapid extraction and so remove the indican from deleterious surroundings in the leaf tissue.

(2) Promote rapid hydrolysis and so lessen the period of time during which the indican in solution is liable to conversion into products other than indoxyl.

Extraction. Until the hot water extraction previously suggested as the most satisfactory method has been shown to be practicable on a factory scale, it seems necessary to

rely upon the production of acidity by bacterial action in the steeping vat or possibly in the *khazana*, mineral acids being too high in price at present for economic use. It has been found by the Indigo Research Chemist that extraction and acidity bear a close proportional relationship, and endeavour will be made either to isolate bacteria capable of combining acid production with indican hydrolyzing powers, or to use different species for these two purposes either concurrently or in succession.

Hydrolysis. Numerous species of indican hydrolyzing bacteria were isolated by means of indican agar; these were tested for hydrolyzing power and arranged in a relative order taking into account not only this physiological function, but also the opposite destructive action which many of them possessed. There can be no doubt that the very large differences between yields of various factories are due mainly to differences in the composition of the bacterial flora in the steeping vats; how far this may be due to bacteria carried by the plant or to those existing in the *khazana* water is not at present known, but examination of a large number of samples of the latter has demonstrated a very close connection between the actual yield of the factory and the number of hydrolyzing bacteria present in the water supply. Actual cases of increased yield as a consequence of inoculation of the vats of one factory with the steeped liquor from another of higher yield substantiate this view.

In order to make use of the inoculation method it will be necessary not only to obtain efficient species of bacteria but to ascertain the conditions under which it will be possible to introduce them into the steeping vat in sufficient numbers and in a sufficiently high state of activity to influence the style of fermentation therein. This will probably be difficult in view, firstly, of the very large volume of water involved (some seven or eight thousand gallons in each vat, and as many as six to twelve vats in use at one time) and, secondly, of the large number of other bacteria necessarily present already on the plant and in the water. As before pointed out it may be found necessary to remove the possibly deleterious influence of these latter, by use of

hot water extraction, but the economics of this method would have to be worked out before recommending its adoption as a factory procedure.

It became clear very early in this enquiry that no advance could be made in the absence of an experimental factory. Designs were accordingly made and sanction obtained for the necessary expenditure; it is unfortunate that owing to various and numerous sources of delay it has not been found possible to complete the erection and equipment of the factory in time for manufacture of Java plant at the time when it was ready for cutting; it is hoped that even with overmature plant some results of value may be obtained. The factory consists of one range of six vats with six corresponding separate *khazanas* and blowing vats. Four vats are of 100 cubic feet capacity and two of 50 cubic feet. Blowing was preferred to beating on account of the mechanical difficulties of the latter in several small vats, and of the greater possibility of controlling the oxidation and ensuring comparable conditions in all the vats.

Apart from the actual indigo produced the Indigo Research Chemist has kindly undertaken to arrange for complete analytical control of the whole series of operations in each experiment which will naturally afford more insight into the causes underlying differences in the results obtained by variations in the method of manufacture than could be secured merely by weighment of the indigo produced.

The lines of enquiry which will be adopted will aim at determining :—

(1) The possibility of increasing the yield of indigo by introducing specific bacteria into the steeping vats.

(2) The best way of doing this on a factory scale and under factory conditions.

There are indications that the second part of this enquiry will form the major problem and may require a considerable amount of time and labour to bring to a successful issue. It is also evident that should hot water extraction prove economically feasible the difficulties

connected with its solution would be greatly reduced in number.

V. Pebrine.

Further work on this subject was carried out and a Bulletin describing a revised method of examination of moths was published.

The rearing of worms (mulberry) was continued under controlled conditions with a view to determining the following points in connection with the incidence of pebrine.

Some 90 lots were reared under controlled conditions besides many larger broods in a separate *kutcha* house.

Hereditary infection. Broods were reared throughout the year to check the value of the improved method of seed selection and to compare it with the one which has been unsuccessfully used in Bengal during the past ten years. The results of the experiments confirmed the previous conclusion that many cases of pebrine in the moth may escape detection by the ordinary method, which would not do so if examined by the revised one.

Further confirmation was also obtained of the conclusion that a considerable percentage of pebrinized seed may produce worms which can be successfully carried through to the cocoon stage if afforded sufficient space and suitable food, whereas comparatively unfavourable conditions of life such as are frequently found in rearing houses as a consequence of ignorance or carelessness, would have ensured their failure to spin. Such worms, however, cannot be used for seed production, the resistance to the disease consequent upon the favourable conditions of life seldom being sufficient to do more than prevent the rapid multiplication and spread of the parasite in the body of its host which characterizes the disease in less suitable surroundings.

One of the inherent difficulties of this work is the unavoidable length of time required for the experiments; this is due to the impossibility of ascertaining either the success of an artificial infection, or even whether the vitality of the pebrine parasite has been affected by treatment, until

an obviously diseased condition has been produced in the worms as a result of the use of such infective material. This may require several weeks' incubation during which the difficulty of ensuring the absence of other sources of infection and the possibility of adventitious disease in the controls, add uncertainties to the results and make numerous duplicates necessary.

Infection through contagion or ingestion of the parasite. The necessity of work upon this second source of the disease will be realized when it is pointed out that perfectly healthy seed if reared in infected surroundings will give rise to worms which may die whilst still in the larval stage, before spinning; it is the loss of time and the money thrown away upon feeding such worms for several weeks that has caused many thousands of silkworm rearers to forsake this avocation in favour of some less precarious mode of earning a livelihood. Numerous experiments under controlled conditions have confirmed my previously expressed conclusion that the principal, if not the only, means of infection other than by hereditary transmission is by ingestion of the spore form of the parasite with the food. In this country at any rate, there seems to be no need at present to assume that any other method is of serious consequence; the prime importance of avoiding this one alone, and the great inherent difficulties of doing so, will sufficiently engage the attention of rearers for some years to come.

Experiment here has not only shown the infective nature of the pebrine spore, in India as in Europe, but has demonstrated its presence in great numbers in the dust of rearing houses and what is still more important in that of seed selection buildings. Most of these loose spores are thrown out of the gut of the infected but still feeding worm, along with the fæces, and being present in the latter in enormous numbers remain to some extent upon the leaves upon which the diseased and healthy worms alike are feeding. This naturally results in their passing with the food into the gut of the hitherto uninfected worms to act as sources of disease. Thus hereditary infection of a small percentage

of worms becomes a source of disease for a much greater number and for this reason alone would require suppression.

Infection once introduced into a rearing house is carried on and spread through the agency of dust, human beings, and insects, carrying the spores of the disease, not only from one part to another part of the same house, but almost certainly to other houses in the same neighbourhood. Similarly the spores may be spread through widely separated areas to a lesser distance by wind, but to unlimited ones by infected material such as cocoons and seed eggs sent by post, the latter material, although hereditarily free from disease, possibly contaminated during examination. My own observations in seed selection nurseries, lead me to conclude that this is by no means an unlikely means of spread of infection, aggravated in most instances by the faulty technique of examination which results in the accumulation of infective material in the selection buildings.

The persistence of infection in a rearing house will depend upon several factors about which at present very little is known, but as to which further information must be obtained if any success is to attend the efforts of rearers to avoid losses by diminishing the sources of infection. Nothing is known in India as to the action of the various antiseptics, such as copper sulphate, at present occasionally used for the disinfection of rearing houses. It has been assumed that they are efficacious, but so far as I have been able to ascertain this assumption is based, like the examination of moths, upon another one, that what is good in Europe is good in India; there is more reason indeed for assumption in the case of antiseptics than there was for the other one connected with seed selection, but it would seem highly desirable to test the efficacy of such antiseptics as are available and reasonably cheap, by actual experiment. Owing to exigencies of other work I have been obliged to confine experiment during the past season to another, and what appeared to me to be a more important point, namely, the viability or persistence of infective power

of the pebrine spore under varying natural conditions; this point seems to require elucidation as a necessary preliminary to such enquiries as the one above referred to, and the success of antiseptic measures would largely depend upon their having been devised with due knowledge of the resistance of the resting stage or spore form of the parasite to natural antagonistic or destructive agencies such as desiccation or heat.

Progress in experiment on this subject is necessarily slow for various reasons. Firstly must be taken into account the fact that no means is at present known of determining either the vitality or the infective power of this protozoal parasite except by the success or otherwise of experimental infection of its natural host; this at best requires several weeks to show any positive result, and in any case may fail to do so from causes other than loss of infective power or vitality by the parasite, such as unduly high resistance of individual hosts, making it necessary to use large numbers of the latter to eliminate this source of error as far as possible. Numerous other disturbing factors have to be allowed for such as the possibility of accidental infection from adventitious causes either in the worms under experimental infection or in the controls. Further work on the purely protozoological side of the question is required before absolute knowledge of this part of the problem can be obtained, and this in my opinion must be carried out, and carried out in India, before it will be possible to advance in actual practice much beyond the present empirical stage of treatment.

So far I have been able to ascertain with some certainty a few important points with regard to the persistence of vitality of the infective organism, amongst which may be mentioned the interesting fact that desiccation for as much as six months did not destroy the infective power of the pebrine spore, whereas moderate moisture at the same temperature rendered it innocuous in one month. It will be obvious that more complete knowledge of this sort would be invaluable in introducing any modifications in existing practice, especially those depending upon avoiding certain

climatic conditions either by confining rearing to certain seasons or to certain districts. It might be possible to make use of this line of enquiry to elucidate what appears to me to be a problem of great importance in dealing with preventive measures, not only for this but for many other parasitic infections, especially those of cultivated crops. Many parasites, both animal and plant, go through a resting stage in their life-cycle, frequently in the spore form, as in the case of *Nosema* and of many bacteria and fungi; this resting condition usually serves the purpose of carrying the organism through a period of existence during which its surroundings are unfavourable for continued vegetative activity, either by reason of failure of food supply or of seasonal or climatic changes. Emergence from the spore condition normally takes place when conditions once more become favourable for active growth, and the time of such emergence is generally determined by the coincidence of some natural stimulus with such favourable surroundings. In the case of the pebrine spore the ordinary stimulus seems to be the combination of moisture and suitable temperature found in the gut of the silkworm, which initiates the series of internal changes in the spore, culminating, under the added influence of acid found in the gut, in the protrusion of the flagellum and the emergence of the amœbula. It seems probable that the deleterious effects of continued moisture upon the vitality of the spore may be due to prematurely induced resumption of vital activity in the latter, not indeed carried so far as germination, in the absence of other necessary stimuli, but resulting, in the absence of appropriate environment for its continuation, in either partial or total loss of vitality. Other similar cases of abortive germination are common in nature, and it would appear to be worth while to make a careful study of the possibility of artificially inducing it in such a way as to destroy various parasitic organisms, in cases where the use of antiseptics or heat is not practicable. It might, for instance, be found possible to induce premature activity in the pebrine spores infesting rearing houses, simply by moistening the walls and floor at a time of year

when they would otherwise be completely dry, and although in the case of silkworm rearing the use of possibly more certain antiseptic methods is not generally prohibited by considerations of cost, in many other instances, such as occur in connection with agricultural operations, this principle might be worked out and applied where water, either natural or artificial, is available. Irrigation, for instance, might be utilized at the proper time to ensure premature germination of parasitic soil organisms, such as bacteria and fungi in the resting spore stage, or even to induce such unseasonable multiplication of the vegetative forms as to result in their exhaustion or auto-intoxication. This principle is actually made use of in the elimination of weeds from arable soil. It seems probable that similar premature or unduly rapid stimulation of embryonic activity may be responsible for the failure of crops in the seedbed or in the field, especially where germination has perhaps been inhibited by interference with the orderly sequence of enzymic activities characteristic of embryonic metabolism, such interference being due to abnormal temperature or moisture.

In order to combine such knowledge with further information of a different kind such as the effect of climate or manurial treatment upon the nutritional value of the mulberry leaf, and the resulting action upon the resistance of the silkworm to infection, much more investigation is necessary, but in view of the undoubted fact that the production of raw silk in India depends primarily, just as it does in Europe, upon the possibility of avoiding diseases amongst the silkworms themselves, of which diseases by far the most destructive is pebrine, it seems clear that such investigation is a necessary antecedent to any successful attempt to resuscitate the silk industry in India.

It may be said, therefore, that although an important step in advance has been made in the provision of an effective adaptation of Pasteur's classical method of seed selection to Indian conditions, yet the elimination of any undue percentage of hereditary infection by this means must be

supplemented by the adoption of methods of rearing calculated to avoid subsequent infection, and such can only be carried beyond their present imperfect stage of development by making use of fuller knowledge of this subject than we at present possess. I regard more complete knowledge of the life-history of *Nosema bombycis* and the reciprocal relationships between this parasite and its host as an essential preliminary to any successful solution of the fundamental problem now confronting the promoters of the industry.

VI. Saltpetre.

The artificial nitre beds described in a previous report (*Bulletin No. 68 of the Agricultural Research Institute, Pusa*), were kept under analytical observation during the year; they still continue to yield saltpetre and as this is remarkably free from sodium chloride, this method of adding to the output of saltpetre would have the additional advantage of inviting less attention from the Salt Department than is usually thought necessary in the case of extracts from village earth.

A *nuniah* was brought in during the cold weather and worked his ordinary process successfully with surface scrapings from these beds.

VII. Programme of work for 1917-18.

Major subjects.

1. The decomposition of organic matter in the soil by bacterial action.

2. The reciprocal relationship between bacterial activity in soil and the mineral constituents of the latter with special reference to phosphates.

Special enquiries.

3. Indigo.
4. Pebrine.

Minor subjects.

5. Biological analysis of soils.
6. Bacterial diseases of plants.

VIII. Publications.

1. Hutchinson, C. M. The Pebrine Disease of Silkworms in India. *Bulletin No. 75 of the Agricultural Research Institute, Pusa.*
2. Hutchinson, C. M. Report on Soil Bacteriology for Board of Scientific Advice, 1915-16.
3. Hutchinson, C. M. The Importance of Bacterial Action in Indigo Manufacture.
4. Hutchinson, C. M. A Bacterial Disease of Wheat in the Punjab. *Memoirs of the Department of Agriculture in India, Bacteriological Series*, Vol. I, No. 7.

REPORT OF THE IMPERIAL COTTON SPECIALIST.

(G. A. GAMMIE, F.L.S.)

I. CHARGE AND TOURS.

Charge. I was in charge of the Section throughout the year.

Tours. In October I toured in Khandesh, Gujarat, Belgaum and Sholapur districts; in December, in Berar and the Central Provinces; in January, Gujarat, the Southern Mahratta Country and Khandesh; in February, Gujarat and the Southern Mahratta Country, and in March, Satara District and Gujarat.

II. COTTONS IN THE PROVINCES.

Bombay Presidency.

Khandesh. Excepting for a slight admixture of Upland Georgian cotton which has persisted for many years after its cultivation was abandoned in this tract, the whole of the crop consists of a variety of forms which are botanically aggregated under the species **Gossypium neglectum** of Todaro. Commercially they come under the head of "Bengals," which prevails over the greater proportion of the whole area devoted to cotton.

The varieties comprised within this species are in order of value; *Malvensis*, in most respects equal in quality and staple to Broach but failing to maintain a dominant position here on account of its low yield and ginning percentage; *vera*, slightly inferior to the above and failing on the same points; and **roseum,** a white-flowered variety, which, although producing a cotton of practically no staple, leads the field by its productiveness, hardiness and high ginning percentage so that, at present, it returns to the cultivator

about Rs. 15 per acre more than any other variety of the mixture. After long experiment the Department decided that this was the most profitable type to grow and the farmers themselves have independently arrived at a like conclusion. A large seed farm, assisted by certified cultivators, is established at Jalgaon and great quantities of seed of this low grade type have been distributed throughout the tract. It appears probable that at no far distant future this will replace the old established mixture which, after all, had its good points and many merchants now bewail what they call the deterioration of Khandesh cotton. There are already indications of the setting in of a more insistent demand for finer cottons and it would be well for the Department to be prepared to put out a higher class cotton when the demand for it reaches this tract. Possibly the lowest grade variety will always be the most remunerative but the Department must remember that there is a risk of a great fall in price of such cotton on account of over-production.

I am of opinion that the time will soon come when the Department can safely leave the white-flowered cotton to look after itself and meanwhile attention should be centred on the improvement of the finer varieties.

In the adjoining districts of the Deccan, especially perhaps in Sholapur where a large expansion of the cotton crop has occurred in recent years, there is the same tendency to replace the old *neglectum* mixture with a pure strain of white-flowered cotton. Trials have been initiated to test the values of the other members of the mixture. This tract abuts on the part of the Nizam's Dominions where a particularly fine cotton is grown, probably the best of the Indian cottons, the **G. indicum** of Todaro, and **Bani,** Hinganghat, etc., of the trade. It would amount to a calamity if this fine strain was vitiated with the low grade cotton from Khandesh and Berar although there are distinct indications that the contamination has commenced, as will be seen from the fact that Barsi cotton has deteriorated. Along the Godavari Valley in Hyderabad Territory this

fine variety still exists in moderate purity and it is said that the bulk of the crop is bought on the spot by millowners.

A sample of white-flowered cotton was valued in Bombay as being equal to Superfine Bengal and lower than Fine Khandesh by Rs. 38 per *candy*.*

The Southern Mahratta Country. In the lower portion of Satara and throughout Belgaum, Bijapur and Dharwar, the prevailing cotton is of the species **G. herbaceum,** known as Kumptas in the trade and, in addition, there is, in the Dharwar District, an acclimatized Upland Georgian, originally from the United States of America, known commercially as Dharwar-American. For some years past introduced Broach cotton has done well in parts of Dharwar and fetched good prices, but fresh importations of seed are required as a steady deterioration has been proved to occur in this region. In the Dharwar District again, another cotton of Upland type from Cochin-China, known as Cambodia, has been introduced. The success of this crop however varies with the characters of the seasons and for this reason it will probably never become popular.

The **Kumpta** cotton is very uniform in type throughout the whole tract. It is hardy and well suited to withstand the vicissitudes of the climate. Its chief defects are a rather low ginning percentage (25) and the rosy colour of its cotton in bulk, which detracts from its value in the eyes of the Bombay trade which prefers a quite white cotton. By selection the ginning percentage has been raised by 4 per cent., its yield has also been increased and it will possibly be still further increased by the fact that a tall, shortly branched form of the plant has been found to transmit a strain of higher production and, strange to say, this style of plant appears to be the more productive in all species of Indian cottons.

How Kumpta has increased in value by selection will be immediately seen from the following figures :—

With ordinary cultivator's Kumpta giving a return of Rs. 53 per acre, one Kumpta selected type on the Dharwar

* *1 candy* = 784 lb.

Farm gave Rs. 132, a second, Rs. 130, a third, Rs. 114, and a fourth, Rs. 110. On the Gokak Farm, with the local Kumpta at Rs. 120, one selection was valued at Rs. 135 and another at Rs. 136.

These results from Kumpta are valuable as they go to show that a great advance can be at once effected by selection and that the advance even in further selection is really continuous.

By careful analysis we have realized that the **Dharwar-American** really consists of two species, a hairy plant, the true Upland Georgian, and a smooth one, the New Orleans. We have also ascertained as the result of tests that the former possesses qualities denied to the latter, *viz.*, hardiness, greater immunity from insect attack, and better cotton accompanied by a higher production. Steps must be taken gradually to eliminate New Orleans from the fields. A sample of pure Upland Georgian was valued at Rs. 505 per *candy* while one of New Orleans at the same time was valued at Rs. 490 – a difference of Rs. 15 per *candy*.

Although these American cottons were introduced into the district so many years ago, they have not yet become thoroughly acclimatized, and it is the practice of the people who cultivate these to grow always a mixture of Kumpta plants in their fields. The Dharwar-American entirely fails in some years, but Kumpta is certain to give some return even in the worst of seasons. The Dharwar-American matures most of its cotton in advance of Kumpta so that a fair part of the former is picked pure, but an enquiry is to be undertaken to find out whether the inevitable mixture is a matter of any concern, the general idea being that it is not. Anyhow as the growing of the two sorts together is done to minimize the risk of loss it will be difficult to persuade the farmers to give up the practice and, fortunately, it may not be necessary to do so.

Cambodia cotton was introduced into the district a few years ago, but it is still more uncertain than Dharwar-

American, and owing to its similarity in external characters to that variety it is very difficult to detect admixture in the fields although this has gone on very rapidly.

Broach cotton has done well on a strip of country on the eastern side of the district where the south-west monsoon sets in early, but there is little chance of its ever extending beyond this tract.

The prices realized in the years 1913-1916 for Broach seed cotton of the special class, which ginned 34 on an average, have been 20 to 25 per cent. higher than those of the local cotton, and the lowest class of Broach cotton, with a ginning percentage of about 29·5, has fetched about Rs. 20 more than the local Kumpta.

The Manager of the cotton mill at Gokak supplied the following note on a test made with selected Kumpta of the Dharwar Farm and compared with local Kumpta of many parts of the Kumpta tract :—

"The cotton was considerably superior to any of the Kumpta cottons as supplied either direct by the ryots or which we have obtained from the near markets; it is bright, clean, long in staple and uniform and of middling strength; from it we spun 3 counts, *viz.* :— 20's, 30's, 40's. The yarn ran smoothly and demanded very little attention from the workpeople, and we would no doubt have received better results had we had sufficient cotton to make it worth our while to alter our machinery so that it should be spun into yarn under the best conditions.

"The loss in the blow room amounted to 8 per cent.

"The yarn gave the following tests :—

Counts	Actual average count	Actual average strength
		lbs.
40's	38·4	$34\frac{3}{4}$
30's	30·3	$46\frac{1}{2}$
20's	19·5	$82\frac{1}{4}$

"Against this we give you the result of 20's spun from Kumpta and other cotton from the places named:—

Name	Blow room loss	Average count	Strength
	per cent.		lb.
Kudchi	9½	20·4's	59½
Hubli	10	19·6's	65
Athani	11	20·6's	59½
Shedbal	10½	20·6's	59½
Jamkhindi . . .	12	19·5's	62
Mudhol	14	19·6's	69
Bagalkot . . .	14	20·1's	60
Bijapur	13½	19·6's	68
Sangli	13½	20·2's	65

"The cotton you supplied is better than the Cambodia we have seen this year and fully Rs. 20 per *candy* better than Kumptas from the surrounding districts. We send you a sample knot of 20's spun from Dharwar selected and ordinary Kumptas."

Dharwar-American has stood the test of time fairly well and, if its weaker companion, New Orleans, is cleared out, it may be a more certain crop than it is at present.

This type is grown late in parts which enjoy the advantage of two rainy seasons, and the north-east monsoon is absolutely essential to it. It is found mixed to a greater or less extent with the local Jowari Hatti or Kumpta and also less evidently so with Cambodia round Ranibennur. I have already stated that the mixture with Kumpta may not be taken as fraudulent.

As regards results from the separate tests with Upland Georgian and New Orleans during three successive seasons, the Upland type gave 50 lb. more seed cotton per acre than the ordinary field mixture, it gins 3 to 4 per cent. more and in value it commands Rs. 10 to 15 more per *candy* of lint. The New Orleans not only gives a lower percentage and poorer quality but it is behind in out-turn. It has also been

proved in the Punjab and United Provinces that the Upland Georgian is hardier and more resistant to insects and disease than the New Orleans. Of the multitude of exotic American cottons which have been tried only two of the number are worth introducing. They are far superior to the local article in quality, but they fail in yield as yet.

The area under Cambodia is gradually extending. But as has been said above, taking one season with another, Dharwar-American is more certain, and therefore the latter will continue to hold the field.

During the last six years the special class of Cambodia cotton, with a ginning percentage of 37 and over, commanded on an average Rs. 60 to Rs. 70 more per *naga* (*naga* = 1,344 lb.) than the ordinary Dharwar-American and the lowest class, with a percentage of 33·5, Rs. 30 to Rs. 35 more. Last year, however, the difference ranged from Rs. 65 to Rs. 100 per *naga*.

Gujarat and Kathiawar. Here we have the last great cotton area in Bombay. The prevailing species is *Gossypium herbaceum* of Todaro, the varieties of which are usually restricted each to a certain class of soil. On the whole the distinctions are only dimly appreciable in the external characters of the plants but they are easily detected in the lint, so that it is only when the crop is ripe that the varieties can be readily distinguished.

Starting from the southward as far north as the Tapti, we have the **Navasari strain,** which is accepted as the best cotton in India. The good soil, genial climate and proximity to the sea, all favourably influence the quality of this cotton.

Further north, about as far as the Narbada, there is the **Surti Broach strain,** which is only slightly inferior to the Navasari.

From here, however, deterioration steadily sets in. In the Broach District and adjoining parts the strain is contaminated with a high ginning, short-stapled form of uncertain ancestry called **ghogari.** Its antecedents are doubtful but it may be a cross between Wagad (to be mentioned

later) and Surti Broach. Here also in the tract called the Kahnam a variety called *kanvi* exists. It apparently cannot claim to be considered a distinct race but is probably in no way different from Surti Broach or even Navasari.

The only remaining form of *herbaceum* which reaches further north than this is the **Lalio,** which used to be distinguished by the very pendulous nature of its cotton when ripe. A great deal of the cotton which goes under this name is possibly Broach; anyhow Lalio, as we used to know it, has almost gone out of existence. On the lighter soils of North Gujarat different species of cotton appear and this mixture is in its greatest intensity in the Kaira and Ahmedabad districts. A perennial variety, *G. obtusifolium*, Todaro, the Rozi of Gujarat, is grown in fields, always as a mixture.

In Kathiawar there are the same cottons as in Gujarat, on the other hand *wagad*, a form of *herbaceum* in which valves of the bolls remain closed in the ripe bolls, is a prevalent species as is also a form of *neglectum*, called *mathio* which is said to have been introduced into Kathiawar about 1891 and gained ground after the famine year of 1899 when the local cottons were wiped out with drought.

The decreasing values of cottons as we go up from the southward undoubtedly depend on the accompanying differences of climate and soil.

Thus, if we take the value of Broach at Rs. 300 per *candy* of 784 lb. as the basis, we have—

	Rs.
Navasari	360
Surat	330
Broach	300
Kanvi or Broach in the north of Broach	285
Lalio	285
Ghogari	260
Wagad	295
Mathio	255—260
Dhollera	250

The quality of the Broach cotton is already so good that it has been difficult to effect anything tangible in its improvement, but at the Surat Farm where experiments with this end in view have been carried on uninterruptedly for many years, certain strains have been established, and these are distinctly more profitable than the local unselected cotton. Thus while ordinary Surti Broach, on the farm, gives a gross return of Rs. 89 per acre, Selection 1A gives Rs. 106, and Selection 11, Rs. 98.

Taking the average of five years, local cotton has a ginning percentage of 33·2; Selection 1A, 36·6; Selection 11, 35·2. These improved cottons are now grown on an extended scale by villagers under departmental supervision and a premium of 5 per cent. over local rates is paid by traders for the produce, but there are indications to show that this is considerably below their intrinsic value.

In the Broach District the local cotton is being mixed with an inferior type called *ghogari* as it brings in more money at present to the cultivator. From the results of the Broach plot for three years *ghogari* yields on an average 15 lb. more *kapas* per acre than the *Broach Deshi.* This together with the high ginning will pay about Rs. 3 more per acre to a cultivator.

Realizing that the people are determined to have *ghogari* the Department has started a farm at Broach to see what can be done either to improve it or to develop uniform strains. Four more or less distinct types have been separated, but the test has not been in operation long enough to furnish any results of a decisive nature. The fibre is reported on in Bombay as being short and weak and the change of quality in the Broach cotton generally is not approved of. In valuations of successive years before 1908, the difference in price between Fine Broach and Fine Surat was ordinarily Rs. 10 per *candy*, but of late years the market has been paying Rs. 30 per *candy* more for Fine Surat, and this fact supports our contention that Broach cotton has deteriorated simply by reason of the steadily increasing *ghogari* mixture. In Broach as in Khandesh and Berar

it is plain that the deterioration in quality is not due to natural causes but has been brought about by the deliberate selection of the most inferior type in the prevalent mixture. *Ghogari* is spreading southwards and it is not looking very far in advance to foresee that the whole of the South Gujarat cotton country will become contaminated with it.

In the northern part of Gujarat, with the exception of *wagad* which covers large areas to the west of Ahmedabad and which is also a cotton of good type, we have a heterogeneous assemblage of varieties which are grown capriciously throughout the area. For instance, in Ahmedabad District, *lalio*, *wagad*, *mathio*, *ghogari* and *rozi* are found not in the same fields of course but scattered indiscriminately.

Central Provinces.

In the Central Provinces the mixture of cottons in the fields is exactly as described for Khandesh in the Bombay Presidency, with the addition that a sort of acclimatized Upland Georgian from Chhutia Nagpur called *Bhuri* has been introduced into wilt-infested areas on account of its resistance to the disease. *Bani* or Hinganghat which spreads in from the direction of the Hyderabad Territory has rapidly gone out of favour on account of its low yield and low ginning percentage.

As in Khandesh, the white-flowered *neglectum* or **roseum** is being distributed lavishly to the exclusion of all other varieties. That there is abundant justification for this course is proved by the following figures: *roseum* and *Saugor jari*, both white-flowered, give a gross return per acre of Rs. 57; the yellow-flowered varieties, *Berar jari*, Rs. 41; *bani* Rs. 39; *Malvensis* Rs. 33 and *vera* Rs. 31 respectively. Two Cawnpore Selections K22 and K7 give Rs. 43 and Rs. 33. *Bhuri* is worth Rs. 51 per acre.

At Sindewahi in the Chanda District, where attention is being paid to the possibility of growing better cotton under irrigation, a very promising cross between *bani* and *deshi Lahore* has been tested but in yield it still holds a minor position. *Cambodia*, under the same conditions, gives

a gross return of Rs. 202 per acre; *roseum* Rs. 122; *Sindewahi cross* Rs. 81 and *Bhuri* Rs. 31. Cambodia is a plant adapted for irrigation and it should always occupy a place in any scheme proposed for growing irrigated cottons.

For the purpose of rigidly testing the **Sindewahi Cross** throughout the *neglectum* area, it was grown at the following places. The results here given are based on valuations alone, as the crop on account of the abnormal season was not good and no dependence could be put on acreage outturns. Taking the market price of the day of Fine Broach at Rs. 100, we had in Khandesh; Dhulia at 101·2, Jalgaon at 97·3; in Berar at Akola 97·3; in the Central Provinces at Sindewahi at 95·4; in the Panch Mahals at 97·3; in Central India at Indore 76·8. The test is being repeated during the present season at the same places. On the whole we may assume that it is possible to have a short season cotton which compares very favourably with Fine Broach. The ginning percentage is 35, which is about the highest obtainable in Broach.

On the eastern side of the Central Provinces Mr. Clouston has decided to exploit the *bhata* soil, which is a sort of laterite covering large areas of country and bearing only coarse grass, *kodra* (*Paspalum scrobiculatum*) and a little rice. At Chandkhuri, under irrigation and green-manuring, this soil grows most excellent sugarcane, groundnut, *jowar* (*Sorghum vulgare*) and Alexandrian clover. The plots of **Cambodia** and **roseum** were very good indeed. The value of the former works out to Rs. 172 gross per acre and of *roseum* Rs. 77.

A great deal depends on the amount of irrigation that can be supplied, but it seems as if a new field has been discovered for the cultivation of the high class Cambodia cotton.

Central India.

In Central India, some varieties of local and other cottons were tried in Malva but, owing to the abnormal character of the season the out-turn and other figures were not taken. Samples from Dewas and Ujjain were considered

the best and Indore came last. The cottons of Malva are naturally excellent and good results are anticipated from the trials which have now been put in hand throughout the tract.

United Provinces.

From the United Provinces, seeds of **K22** were procured from Cawnpore for trial throughout the *neglectum* area. The test is being repeated and in the last season the following comparative results were recorded. Taking the price of Fine Khandesh at Rs. 100 we have it at Cawnpore at Rs. 101; in Khandesh, at Jalgaon Rs. 97 and at Dhulia Rs. 104; at Indore in Central India at Rs. 103; at Dohad in Panch Mahals at Rs. 85. The trials must of course be continued to obtain decisive results but so far we may take it as being only slightly in advance of Fine Khandesh.

Fourteen samples of Upland Georgian cotton (the so-called **Cawnpore-American**) were received, for valuation and opinion, from the United Provinces. Two samples were good for spinning 24's, 4 from 20's to 16's, 5 from 12's to 14's and 3 for 10's and there is an extreme range of value per *candy*—of Rs. 70. This clearly shows the amount of variation which may exist in one or any species of cotton and the method of selection will depend on the aim of the grower which may be assisted or frustrated by the many variations in external conditions.

Acknowledgments. I have again to thank Messrs. Tata & Sons of Bombay who have assisted me for years in estimating the values of many samples I have submitted to them. My thanks are also due to the Secretary of the Bombay Chamber of Commerce for the gift of standard trade samples of Indian cottons.

III. Programme of work for the year 1917-18.

Major.

(1) To visit and advise on points regarding cotton and its cultivation whenever requested to do so by the Provincial Departments of Agriculture.

Minor.

(2) The study of the behaviour of *Bhuri*, Cambodia and other such cottons in non-cotton-producing tracts as detailed in the last year's programme, will be continued.

(3) An enquiry into the manurial requirements of cotton will be continued.

(4) Researches on the botany of cotton will be continued.

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OF THE

Agricultural Research Institute, Pusa

(*Including the Report of the Imperial Cotton Specialist*)

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INTRODUCTION.

It seems unnecessary to repeat that this volume contains the reports of the various scientific workers at Pusa, written in their own words, and that for them each officer is solely and individually responsible. They stand or fall by the verdict on the value of their work passed by workers on the same subjects in the scientific world, and although the misinformed or intentionally vicious criticism to which they were subjected in a certain newspaper last year caused some annoyance, such criticism fortunately does not affect the true estimate of the work which is formed by the scientific world whose opinion is the only one that really counts.

With regard to the criticism in the article referred to, " that one searches in vain for a clue to the particular aims with which and the manner in which the activities of the 'Imperial scientific sections' are co-ordinated and directed or what their labours all amount to in the end from the standpoint of Indian Agriculture as a whole," I need only remark that of this Provincial Departments of Agriculture are the best judges nor do I think that they will endorse the views of the newspaper critics.

The widespread distribution of the Pusa wheats, tobacco and other improved seeds: the solution of various important chemical and bacteriological problems of general application: the recommendations of mycological and entomological methods of control and prevention are appreciated throughout the provinces by whose verdict and that of other scientific workers of repute we are prepared to stand.

J. MACKENNA,

Director, Agricultural Research Institute, Pusa.

SIMLA,

10th Sept., 1918.

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Scientific Reports of the Agricultural Research Institute, Pusa

(Including the Report of the Imperial Cotton Specialist)

1917-18.

REPORT OF THE DIRECTOR.

(J. MACKENNA, C.I.E., I.C.S.)

I. CHARGE AND STAFF.

Charge. I held charge of the office of the Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, throughout the year. From the 8th of October, 1917, I also acted as President of the Indian Cotton Committee in addition to my own duties. Mr. Wynne Sayer held the post of Assistant to the Agricultural Adviser during the year except for a month from the 3rd September, 1917, when he was on privilege leave.

Staff. Dr. W. H. Harrison was appointed Imperial Agricultural Chemist from the 11th November, 1917, in succession to the late Dr. J. H. Barnes.

Mr. F. M. Howlett, Imperial Pathological Entomologist, on return from leave, resumed charge of his duties on the 28th August, 1917.

Mr. G. S. Henderson, Officiating Imperial Agriculturist, was appointed a member of the Indian Cotton Committee, and acted as such in addition to his own duties. From 6th February, 1918, he was deputed to Mesopotamia to advise the General Officer Commanding as to the methods to be

adopted to ensure the development of local resources, and has now been appointed Controller (Agricultural Requirements, Mesopotamia) under the Munitions Board. Mr. Wynne Sayer, Assistant to the Agricultural Adviser, has been placed temporarily in charge of the work of the Imperial Agriculturist in addition to his own duties.

II. Work of the Institute.

Scientific Work. The more important enquiries of the year were the following :—

On the Pusa farm permanent manurial and rotational experiments form an important piece of work. But the most important work is the breeding of pedigree herds of cattle : (*i*) a pure-bred pedigree herd of Montgomery cattle and (*ii*) a cross-bred herd (Montgomery × Ayrshire). The results of crossing are so far very favourable. Alibi, the first crossbred heifer to complete her lactation period, has given over 7,000 lb. in a lactation period of 10 months—nearly double the quantity yielded by a good Montgomery cow. The Ayrshire-Montgomery cross bullocks have also proved good workers. Pusa is now able to supply good stock to cattle breeders and zamindars. A sale of surplus stock was held in March when the 53 head offered were very keenly bid for and realized very handsome prices. Another sale is to be held early in December.

The results of the cross-breeding work at Pusa are of very great importance in view of the known shortage of cattle in this country and their low milk yield.

In the Section of Chemistry the utility of Dyer's method of estimating the available plant food in highly calcareous soils is being investigated and the relationship of the gaseous products of decomposition to the paddy soils, particularly with reference to carbon dioxide and hydrogen, is being studied. The question whether or not the use of ammoniacal manures can be advantageously combined with green-manuring in the case of the paddy crop is also under examination. As regards sugarcane, investigations into the effect of storing canes by clamping and of windrowing are in hand. The importance of these investigations lies

in the fact that the adoption of these methods if found economical will tend to lengthen the working season for a sugar factory in the North-West Frontier Province.

In the Section of Botany the most important work is in connection with wheat both as regards seed distribution and wheat breeding. Another crop receiving attention is Java indigo. Besides the selection work on this crop, its root system and the effect thereon of any alteration in the soil conditions and also of cutting back to varying degrees are being investigated. The Howards are devoting much attention to the improvement of fodder production and fruit culture in Baluchistan as also the sun-drying of vegetables and the raising of the wheat crop on a minimum amount of water.

In the Mycological Section the "ufra" disease of rice claimed a very large amount of Dr. Butler's attention. Among other important diseases under study in this Section are the black band disease of jute, black thread disease of rubber, die-back of chillies and the *tikka* disease of groundnuts.

In the Section of Entomology the most important work of the year was in connection with the pests of sugarcane. The Entomological Department have been able to distinguish no less than 10 different forms which hitherto passed under the name of *Chilo simplex*. The question of alternative wild food plants of these borers is being investigated. Experiments to test the best methods of storing grain have shown that grain and pulses remain perfectly safe and in good condition when stored under a layer of sand. The enquiry regarding the occurrence within the Indian Empire of any insects which may be utilized as efficient checks on the growth of *Lantana*, a weed pest, is still in progress. Life-histories of various insects were studied and useful work in connection with bee, lac, and silkworms done during the year.

In the Section of Pathological Entomology some work has been done on cheap repellants to prevent Tabanidæ

attacking camels and so help to check the spread of surra among transport and other animals.

In the Bacteriological Section the following questions under soil biology are being studied:—conditions determining maximum nitrification in various types of Indian soils, the formation of bacterio-toxins in soils, nitrogen fixation, green-manuring and phosphate requirements of soil bacteria. The most important work, however, of the Section is in connection with the bacterial aspect of the fermentation taking place in the indigo steeping vats. Great variations are known to occur in the yield of different factories from plants grown under similar conditions of soil and climate and these can be correlated with the differences in the bacterial content of their water supply. The enquiry has shown that it is possible to avoid losses of indigo by altering the character of the bacterial fermentation in the steeping vat so as to secure more complete hydrolysis of the indican contained in the leaf. But, as the Imperial Agricultural Bacteriologist points out, some further work is necessary before it is possible to elaborate a routine method suitable for use in a factory without immediate scientific control.

Equally important is the work which Mr. Hutchinson is doing in connection with pebrine, a disease which has been largely responsible for the decline of the silk industry in India.

The work done by the Indigo Research Chemist, whose headquarters are at Pusa, has been published in the *Agricultural Journal of India* and in a series of Indigo Publications. No mention of that officer's work is therefore made here.

Training. A number of post-graduate students attended the Institute during the year and short courses were given in sericulture. Details are given in the Sectional Reports. The following is an abstract:—

	No. of Students
Agricultural Chemistry	3
Mycology	1
General Agriculture	2

Agricultural Bacteriology (including bacteriological technique in silkworm disease)	5
Entomology	2
Sericulture (short course)	9

Besides the regular students, Mr. B. N. Vakil, B.Sc., of St. Xavier's College, Bombay, worked in the Mycological Laboratory for a short period.

III. PUBLICATIONS.

During the year under report, 8 Memoirs, 11 Bulletins and 2 Indigo Publications (a special series started to embody the work of the recently created Indigo Section of the Institute) were issued.

Twelve publications were in the press at the end of the year.

During the year the proceedings of three conferences were published, *viz.*, the Board of Agriculture, the Second Entomological Meeting, and the First Mycological Meeting. An effort, which it is believed has been appreciated, has been made to make the form of the proceedings of these conferences more attractive.

The Report of the Proceedings of the Second Entomological Meeting held at Pusa in February, 1917, issued in an octavo volume of 340 pages, forms practically an abstract of our current knowledge of Indian crop-pests. There has been a satisfactory demand for it from the public.

It is gratifying to record that the public demand for the Bulletins of the Institute is increasing every year. A second edition of two bulletins had to be brought out during the year; the first edition of the bulletin on "New Agricultural Implements for India" ran out of stock within three months of its issue. There were also many applicants for the bulletin on Water Hyacinth—that serious pest in Bengal and Burma. This bulletin shows how a definite return can be obtained in the process of exterminating what was previously considered a useless and harmful weed-pest. A large number of copies of the three bulletins regarding

the diseases and feeding of camels issued during the year were supplied to the Army Department.

The *Agricultural Journal of India* in its new form is increasing in popularity among those interested in the agricultural, co-operative, veterinary and such like problems in this country. As in the previous two years, a Special Number of the Journal containing a selection of papers on agricultural and allied subjects read at the annual session of the Indian Science Congress, was published.

The grant for publications has remained at the figure of Rs. 29,000 previously sanctioned, but with the continuous rise in the price of paper and other materials it is becoming more and more difficult to keep the expenditure down within the sanctioned amount.

IV. General Administration.

Buildings and Works. During the year under report a bungalow for the Electrical Engineer was sanctioned by the Government of India and the work has been taken in hand. Sanction has also been received for the construction of quarters for the First Assistant to the Imperial Mycologist and also of quarters for the staff of the High English School at Pusa. The condition of the roads and drainage on the estate has been much improved during the year.

Library. In addition to the 1,320 bulletins, memoirs, reports, etc., received in exchange, about 375 new volumes were purchased for the library. The United States Department of Agriculture supplied during the year 30,200 printed subject cards of their bulletins, and these have been arranged according to their subjects. The preparation of a new catalogue of the books in the library is in hand.

Pusa School. The total number of pupils attending the Pusa High School on the 30th June, 1918, was 160, including one girl student, as against 198 last year on the same date.

General Health of the Station. The outbreak of a virulent epidemic of cholera in April, 1918, and the un-

healthy conditions which subsequently prevailed in the villages in the neighbourhood of Pusa contributed to an appreciable rise in the number of patients treated in the hospital and dispensary attached to the Institute. The number of out-patients rose to 20,638 from 11,956 and that of in-patients from 297 to 316. Pusa was the only place in the district where no indigenous case of cholera occurred. Great credit is due to the medical staff for the successful way in which they coped with the increased work. The general health of the station continued to be good during the year under report.

V. Accounts.

The total expenditure during the financial year 1917-18 was Rs. 5,81,723, as against Rs. 5,18,603, during the previous year. The details are given below :—

	Rs.
Office of the Agricultural Adviser to the Government of India and Director of the Institute	2,34,865
Chemical Section	30,783
Mycological Section	46,964
Entomological Section	46,100
Pathological Entomological Section	22,493
Bacteriological Section	30,858
Botanical Section	46,203
Agricultural Section	64,577
Indigo Research Section	58,880
Total	5,81,723

Out of the budget of this Department for 1917-18 a sum of Rs. 27,000 was placed at the disposal of the United Provinces Agricultural Department for expenditure in connection with the continuance of the appointment of Mr. W. Hulme as Sugar Engineer in that province.

A sum of Rs. 15,000 was paid as a grant-in-aid to the Indian Tea Association.

The principal items of expenditure under the annual grant of Rs. 10,000 placed at the disposal of the Agricul-

tural Adviser to the Government of India for special agricultural experiments were as follows :—

	Rs.
Experimental cotton cultivation by the Imperial Cotton Specialist	1,250
Grant-in-aid to the Dairy Education Association, Indian Branch, for the Quarterly Journal of Dairying	510
Fittings and apparatus for the field laboratory of the Imperial Agricultural Bacteriologist . .	1,999
Storage experiments by the Imperial Entomologist .	434
Purchase of silk yarn	454
Grant to the Fibre Expert, for purchase of flax seed	1,453
Pay of a Veterinary Assistant in connection with cattle breeding, a Fieldman for mosquito experiments, and an Assistant for pebrine work . .	1,903

The gross receipts during the year from the sale of farm produce, milk, publications of the Department and other articles amounted to Rs. 19,843 as against Rs. 17,878 in the previous year.

VI. Visitors.

Fifty-four gentlemen visited the Institute during the year under report. Among them were the following :—

The Hon'ble Mr. H. Le Mesurier, Member of the Executive Council, Bihar and Orissa; Sir Frank Sly, President of the Champaran Agrarian Committee; the Hon'ble Mr. H. J. Maynard, Financial Commissioner, Punjab; Dr. J. W. Gregory, Professor of Geology at the University of Glasgow and Member of the Calcutta University Commission; Colonel G. J. H. Bell, Inspector-General of Civil Hospitals, Bihar and Orissa; Lieutenant-Colonel Sir James Roberts, I.M.S., Mr. G. E. Fawcus, Director of Public Instruction, Bihar and Orissa; Professor H. Stanley Jevons, Allahabad University; the Reverend Father E. Blatter, Professor of Botany, St. Xavier's College, Bombay; and Mr. Frank B. Hill, a planter in British East Africa. Among the other visitors were officers of the various Provincial Departments of Agriculture, and

planters and zamindars of estates surrounding Pusa. A party of members of the Chanakya (Economic) Society of the Patna College, under Professor Sammadar, also visited the Institute during the year.

REPORT OF THE IMPERIAL AGRICULTURIST.

(WYNNE SAYER, B.A. [IN CHARGE.])

FORENOTE.

Mr. G. S. Henderson was in charge of the post of Imperial Agriculturist till the 6th of February, when he was sent on special duty to Mesopotamia. On return he was put on special duty to purchase agricultural requirements for that country. From the 6th February, Mr. Sayer, Assistant to the Agricultural Adviser to the Government of India, took over charge in addition to his own duties.

From August Mr. Henderson toured extensively along with the Deputy Director, Dairy Farms, Southern Division, to get into touch with the extensive dairy organization which has been formed by the military authorities. From October till the end of January he was a member of the Indian Cotton Committee.

Mr. Henderson has now been made a member of the recently created Central Foodstuffs and Transport Board and appointed a Controller of the Munitions Board to deal with agricultural equipment for Mesopotamia.

I. CHARGE AND STAFF.

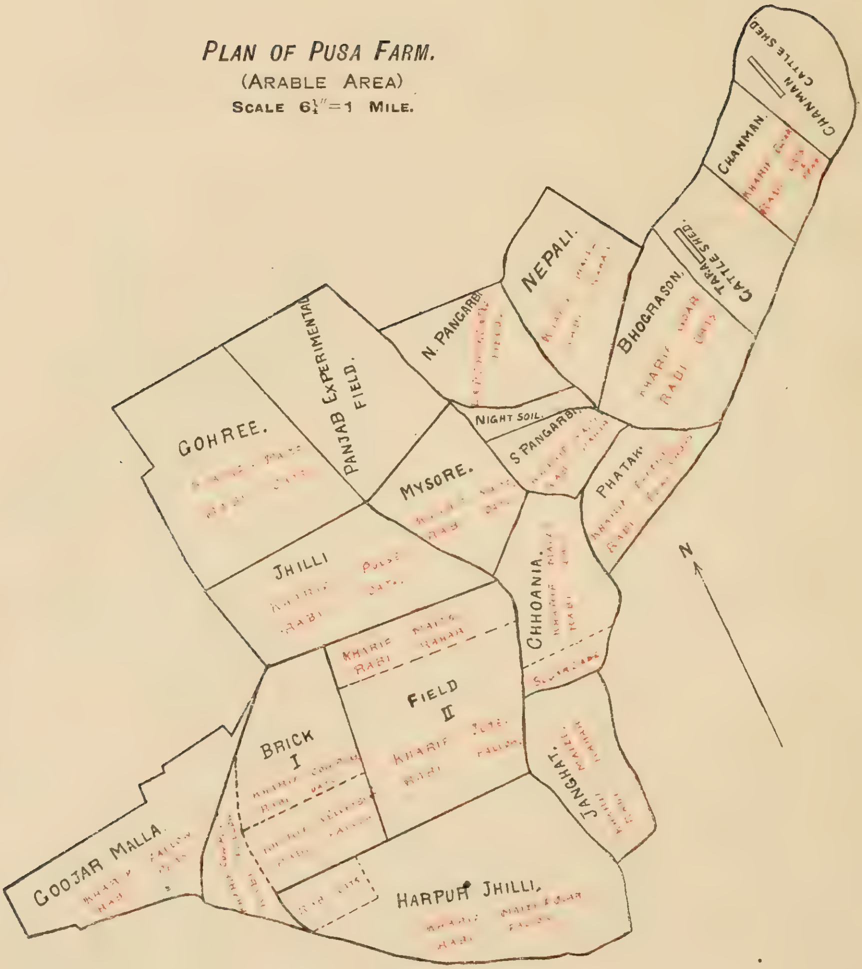
Mr. Wynne Sayer was in charge of the Pusa farm from the 6th February, 1918, in addition to his own duties.

Mr. Imdad Husain Khan, Fieldman, left on 4th November, 1917, for Mesopotamia to work under the Military Department.

Training. Mr. S. N. De, a stipendiary from the Bengal Agricultural Department, joined on 9th August, 1917, for a course in agriculture but left on 21st January, 1918.

Mr. Kalyan Mal Banthia, a stipendiary sent by the Ajmer and Merwara Administration, was admitted to the general course in agriculture from 8th June, 1918.

PLAN OF PUSA FARM.
(ARABLE AREA)
SCALE 6¼″=1 MILE.



II. Pusa Farm.

The Season. The monsoon broke early in June and sowings were completed by the middle of that month. The total rainfall throughout the year (June, 1917 to May, 1918) was 45·54 inches as against 59·67 inches in the corresponding period of 1916-17, the normal rainfall being about 50 inches. The total failure of the cold weather rain made the oat crop a very short one and also affected the yield of peas adversely.

The arable portion of the farm is worked under the following rotation :—

	1st year	2nd year	3rd year
Kharif * . .	Maize for silage and fodder	Maize for corn .	Pulse green crop
Rabi † . . .	Oats . . .	Arhar *(Cajanus indicus)*	Oats

The object of this rotation is to keep the land clean and in good heart while providing grain and fodder for the herds.

By soiling the cattle on the *kharif* pulses it is hoped to do the land even better than under the usual rotation. On the heavy low land portion of the farm this may prove impossible at times, but it is anticipated that it will produce a considerable improvement in the yields on the higher sandy lands in future years.

The cropping of the various fields of the arable area for the season under report is shown on the plan of the farm given here, and the yields were as follows :—

1st year rotation. Kharif maize cut green for silage or fodder (a dressing of farmyard manure at 10 tons per acre or 10 maunds oilcake per acre being given before sowing); four fields aggregating 135 acres down under this crop

* Crop sown in monsoon.
† Crop sown in winter.

averaged 200 maunds per acre; average income Rs. 50 per acre; working costs Rs. 20 per acre.

Rabi oats followed in the same four fields and averaged 12 maunds of grain and 25 maunds of straw throughout, bringing in Rs. 40 per acre with a working cost of Rs. 12 per acre.

The best yields were 231 maunds green maize per acre in Chandman and 13 maunds oats in Gonhri.

2nd year rotation. Maize and *arhar* sown together, no manure being applied; maize cut for corn in end of September and *arhar* left throughout *rabi* for grain; 4 fields totalling 80 acres averaged 23 maunds grain from maize and *arhar* combined, bringing in Rs. 70 per acre at a working cost of Rs. 14 per acre—figures covering both seasons.

3rd year rotation. *Kharif* pulse either fed standing or cut green for fodder or ploughed in; four fields totalling 118 acres stood under this crop which was followed by oats in *rabi* over 84 acres; the remaining 34 acres standing fallow for hot weather maize of 1918 which was sown in March. The oats got one maund of super per acre. The cost of the two seasons' crops was Rs. 30 per acre and the income Rs. 70 per acre. The best field Jhilli gave 18 maunds oats per acre.

Sugarcane and jute are the two crops grown which are exceptions to the above rotation. Sugarcane is taken in the first year and jute in the second. These crops are sown from middle of February up to middle of March on moisture conserved by repeated cultivation in the cold weather.

Sugarcane. A number of sugarcane varieties are grown on the farm without irrigation. These varieties for the most part come from Dr. Barber, the Sugarcane Expert. The main crop consists of Red and White Sathi, Purple Mauritius and few other thick canes. The canes were disposed of at 6 annas per maund. In the area sown during the past year the cost of cultivation was Rs. 65 per acre and income Rs. 144-13 per acre.

Jute was grown on 40 acres for seed by arrangement with the Fibre Expert to the Government of Bengal,

but this arrangement will have to be terminated over the main area of the farm as it is impossible to spare this land from fodder crops for the cattle. As jute is a useful crop for low ground which is liable to be flooded during the rains and consequently will not hold a *kharif* crop with any certainty, it will be sown next year in Gujarmalla field which is outside the protective bundh, and consequently has to be left fallow in *kharif* as far as the ordinary rotation is concerned.

Berseem. This seed was imported from Egypt, but it arrived almost too late for sowing. It was sown but the result was very disappointing. About 4 maunds was distributed to various planters who mostly reported that they received it too late to sow. It will be given a proper trial this year.

Experimental work. This work was continued in the two fields, Punjab and North Pangarbi, set apart for the purpose.

(*a*) The permanent manurial and rotational experiments were continued. A bad outbreak of wilt among the *arhar* on these plots considerably reduced yields for the year from some of these plots.

(*b*) The green-manuring experiments carried out in collaboration with the Imperial Agricultural Bacteriologist, were continued in the Punjab field on the newly tested plots. The results are given below :—

Particulars	Yield of oats (grain) per acre	Particulars	Yield of oats (grain) per acre
	Mds.		Mds.
3 times san hemp fermented with 3 cwt. superphosphate per acre.	24	3 times san hemp fermented without superphosphate.	18
6 times san hemp fermented with 3 cwt. superphosphate per acre.	32	6 times san hemp fermented without superphosphate.	19
San hemp ploughed in with 3 cwt. superphosphate per acre.	25	San hemp ploughed in without superphosphate.	15
Superphosphate alone 3 cwt. per acre without green manure.	14	No superphosphate and no green manure.	$12\frac{1}{2}$

These plots will all be cropped with maize in *kharif* to test the residual effect.

(*c*) Experiments in collaboration with the Imperial Mycologist for determining a method of dealing with die-back (wilt) in the chilli crop were started in the year under report and will be continued.

(*d*) Fourteen varieties of the more widely-known wheats were under trial. The average yield per acre from all varieties was 17 maunds. The best yields were :—

	Maunds
Lal of Jhelum	24
Muzaffernagar white	24
Pusa 12	22
Maroo Boojee (Sindhi)	18

These trials will be continued next year from carefully selected seed when Federation and other Australian wheats which have done well in India will be brought in.

(*e*) The experiments for testing yields of green fodder with yields of seed and comparative economic value of the common leguminous crops were continued. Florida Beggar weed, velvet and soy beans, *val* (*Dolichos Lablab*), *guar* (*Cyamopsis psoraloides*), *math* (*Phaseolus aconitifolius*) and *urid* (*Phaseolus radiatus*) being tried in *kharif*, while white and purple peas, *khesari* (*Lathyrus sativus*), *val* and gram varieties and *math* were sown in *rabi*. They will be continued next year.

(*f*) Experiments with Java and Sumatrana indigo were carried on in collaboration with the Indigo Research Chemist and the Imperial Agricultural Bacteriologist. These will be continued over a period of years and the results will be dealt with from time to time by the Indigo Research Chemist and the Imperial Agricultural Bacteriologist in their respective reports.

The testing of the remainder of the plots laid out in Punjab field continued. Crops for the various experts were grown in North Pangarbi and a set of experiments on *rahar* wilt in collaboration with the Imperial Mycologist

and the Fibre Expert to the Government of Bengal were laid down.

Buildings and Machinery. Two new pit silos have been dug. This type of silo has proved a great success and vastly superior to the brick tower type, as there is little or no wastage at top, bottom and sides, and the silage does not dry out as is the case in the brick silos owing to the impossibility of pressing them sufficiently tight from the top.

A new silage cutter, Climax, was purchased from Messrs. Shaw Wallace & Co., and was tried during the season; it has a feeder attached to it and the chopped stuff is carried up by a blast and blown through a pipe into the silo.

Five hundred and five maunds of cleaned oats were turned out by the 4′ 6″ Marshall Thresher in one day, which is a record, I think, for India.

Steam Plough Tackle. This tackle consisting of two single cylinder K Class Fowler engines and a disc plough, a gang plough, a disc harrow, a grubber, a zigzag harrow and a roller, worked for 121 days during the year, but the total cost of working this year was Rs. 6,098-8-3, as against Rs. 4,034 for 151 days of last year. The details are given below :—

STATEMENT A.

Showing cost for working and maintaining the tackle in 1916-17 and 1917-18.

Particulars	1916-17. No. of working days 151			1917-18. No. of working days 121		
	Cost			Cost		
	Rs.	A.	P.	Rs.	A.	P.
Labour	1,233	0	0	940	1	6
Coal	1,788	0	0	1,424	9	0
Oil	500	0	0	315	0	0
Miscellaneous stores, etc., and renewals . .	713	0	0	3,418	13	9
TOTAL .	4,034	0	0	6,098	8	3

STATEMENT B.

Showing the above cost divided into following operations per acre in the year 1916-17 and 1917-18.

Particulars	1916-17			1917-18		
	Total area cultivated in the year	Cost per acre	Best day's work	Total area cultivated in the year	Cost per acre	Best day's work
	Acres	Rs. A. P.	Acres.	Acres	Rs. A. P.	Acres
Ploughing .	267	4 6 2	7	170·5	9 3 2	7
Disc harrowing .	498	2 0 9	18	821·5	3 0 3	20
Grubbing .	1,080	1 7 4	25	616·0	4 5 7	26
Zigzag harrowing	41	0 14 9	27	11·0	2 2 6	...
Rolling . .	320	1 5 6	22	173·0	3 14 0	22
TOTAL .	2,206	...	...	1,792·0	...	...

The enormous rise in the cost of spare parts and replacements owing to the war has resulted in a great increase in the general working cost per acre this year. This, however, is due to the absolutely abnormal conditions with regard to imports now prevailing, which have necessitated laying in a stock of spares sufficient to carry one over a considerable period, the possibility of being unable to procure spares in the future having to be carefully guarded against as we are now absolutely dependent on the tackle for cultivation, and the greatest objection to it is the fact that the breakdown of one engine alone is sufficient to render the *whole* tackle useless.

But with the renewals which have been made this year (including a set of new cables which will be good for another 3 years' work) the tackle is now to all intents and purposes as good as the day it started work.

Pusa is far from being a suitable place to test such tackle as several of the fields are too small for economic working, the number of stops and turns being out of all proportion to the area run over; nevertheless as is seen from the figures, the best day's work of the tackle steadily increases and the rapidity and thoroughness with which it deals with the work has greatly simplfied the *rabi* cultivation.

A new gang plough was tried during the year under report and worked excellently—burying its rubbish far more effectively than the disc plough formerly used.

III. Cattle Breeding.

The combined herds totalled 386 head in the year under report.

The Montgomery herd is divided into two portions used as follows :—

(*a*) For selective breeding for milk production.

(*b*) For crossing with the Ayrshire bulls.

The stock under (*a*) are divided into five groups each of which has a separate bull to prevent in-breeding. The stock under (*b*) consists of cows which are not sufficiently good milkers for inclusion under (*a*) and are therefore used for putting with the Ayrshire bulls for the cross-bred herd.

The Montgomery milch herd now contains 119 cows of which 42 have given over 4,000 lb. in a lactation period, 14 over 3,800 lb. and 24 over 3,000 lb.

A rigorous policy of selection for milk yield is being carried on and no cow is being kept on in the milch herd who does not show signs of coming up to the standard.

The best performances among the Montgomery cows during the season under report were as follows :—

	lb.	
Syria No. 182	5,935	Lactation period 10 months.
Joogni No. 142	5,464	
Akli No. 231	5,406	
Kabutri No. 236	4,738	
Roomali No. 140	4,711	

The Montgomery-Ayrshire cross-bred herd now stands at 61 head.

Two $2\frac{1}{2}$ year old bulls, by Lessnessock Wildfire off Montgomery cows, have been taken up for stud purposes.

Six of the heifers got by Mossgeil Titanic in 1915, have calved down and are now milking. They have grown into good type cows, in the majority of cases taking more after their sire than their dam. The photograph (Plate I, fig. 2) of one of them, Alibi, is given with this report and it should be compared with the photograph (Plate II) of Akli, one of the best type Montgomery cows in the herd, which is also given. They have got good, well set on bags, flat and carried well forward, in Ayrshire style—a distinct contrast to the Montgomery type. After calving they all came back to bull in one to three months and are all due to calve again in December, thus showing no sign of the Montgomery tendency to stand off for several months which forces us to maintain continually for long periods a large number of empty dry cows, and which is another obstacle to successful dairy farming with the indigenous cow.

In all six cases their calves were weaned at birth, and this has had absolutely no effect on their mothers' milk yield, which is one of the great improvements this cross effects. These calves which are by Carston Royal Scotch are all $\frac{3}{4}$-bred English, but appear at present similar in all respects to half-breds. Two out of the six unfortunately died but the remainder are doing well. It is proposed to start this year putting half-bred bulls across half-bred heifers, and it will be interesting to see whether the result of this cross will continue to allow of its calves being weaned at birth. It is absolutely essential that this character should be maintained, as with milk at 6—4 seers per rupee—which is a very low price for big towns—when the calf sucks continuously the result is that you rear a calf in the most expensive fashion possible, keeping it on milk during the whole lactation period of the cow and materially reducing your profit

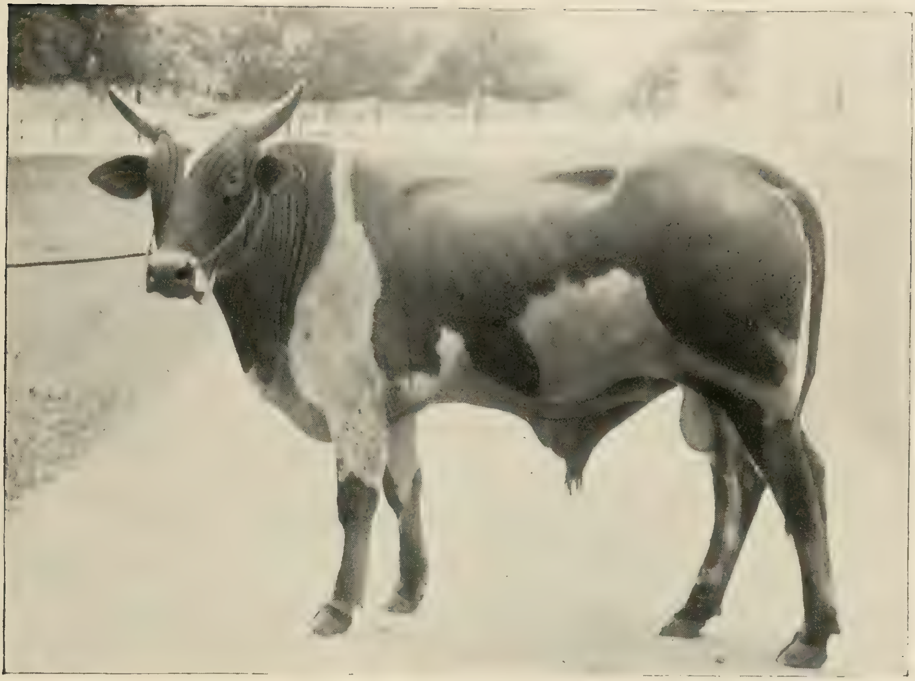


Fig. 1. Cross-bred bull. (Montgomery cow × Ayrshire bull.)

Fig. 2. Cross-bred cow, Alibi No. 3. (Montgomery cow × Ayrshire bull).

One of the best type Montgomery cows—Akali.

thereby, but this is only one of the many points which must be tested in this cross-breeding work.

The first heifer, Alibi, to calve out of the above batch, has given over 7,000 lb. in a lactation period of 10 months. Two of the others are expected to reach over 6,000 lb. The lactation periods of the rest are not yet complete but the figures so far go to show that they will be well above the average.

The castrated stock of the Ayrshire-Montgomery cross have turned out exceedingly quick, strong workers and are proving equally useful for fast as well as heavy work, being very big and massive without being overtopped. The imported Ayrshire bulls, Lessnessock Wildfire and Carston Royal Scotch, kept very fit throughout the year and continue to increase in weight.

A sale of surplus stock was held on the 30th March, 1918, when 53 head—bulls, cows, heifers and calves—came under the hammer. They realized Rs. 5,600, averaging as below—

	Rs.
Bulls	203
Cows	90
Heifers	217
Montgomery bull calves	82
Cross-bred bull calves	93

The best prices were Rs. 300 for a bull, Rs. 230 for a cow, Rs. 340 for a heifer, Rs. 220 for a cross-bred bull and Rs. 175 for a Montgomery bull calf.

There was a large attendance and the bidding which was very keen, especially for the heifers and cows in calf, showed clearly that there is a strong demand for good class cattle in India; while the way in which the cross-bred bull calves were bid for was evidence of the value which they represent for rapidly improving the yield of milch herds.

As the herd is now increasing so rapidly that it has become impossible to accommodate the stock properly in the present buildings, an auction sale will be held at short intervals in future years, the next being in early December. People requiring cattle will do well to come down beforehand and inspect the stock, which will be on view for a month before the sale.

The feeding of the herd has as usual monopolized the output of the major portion of the cultivated area on the farm, and if the breeding up of the Montgomery herd in the five groups already established is to be properly done (and this means retaining all stock bred from these groups for thorough trial), while the collection of data regarding the transmission of characters in the cross-bred herd will also require careful selection and observation among a large number of animals, the arable portion of the farm will have to be entirely devoted to the work of producing fodder and grain for the herd, and the question of finding the land for growing crops such as jute, wheat and sugarcane, etc., on a field scale will have to be considered.

Disease. There was an outbreak of foot-and-mouth disease in 1917 which lasted some three months and resulted in 5 deaths, four of which were suckling calves of under two months old, while a number of young stock were considerably put back by the attack. There was one case of black-quarter in the beginning of May, 1918, which proved fatal, and in consequence all the calves in the herd—some 175 in number—were inoculated against this disease.

Inoculation. It is proposed to have all the young stock inoculated against rinderpest by the simultaneous method. This will enable the cross-bred bull calves sold at auction to go out into the district without risk and should greatly enhance their usefulness, while the ever present risk of having years of work on the cross-bred herd wiped out in one attack will be removed.

The capital value of the herd based on current prices now stands at Rs. 42,000, and the following figures give the

receipts and expenditure in connection with it for the year under review :—

Returns	Rs.	A.	P.	*Cost*	Rs.	A.	P.
Received for sale of milk	6,660	14	3	Budget for up-keep (all labour) . . .	3,900	0	0
7 Montgomery and cross-bred transferred to work cattle	540	0	0	3,695 mds. 7½ seers grain at Rs. 2-8 per md. . .	9,237	15	6
53 head sold . . .	5,600	0	0	9,647 mds. 23 srs. silage at as. 6 per md. . .	3,617	13	6
Sheep and cast stock . .	104	6	0	5,412 mds. green fodder at as. 4 per md. . .	1,353	0	0
	12,905	4	3	3,973 mds. bhusa at as. 4 per md. . . .	993	4	0
					19,102	1	0

The net cost of upkeep and maintenance was Rs. 6,196-12-9.

Sheep Breeding. The sheep breeding experiments were continued during the year under report. As soon as conditions regarding importation improve two new Merino rams will have to be procured for the flock, as much in-breeding is now going on for want of fresh blood.

IV. Publications.

The demand for Bulletins on "Berseem" and "New Agricultural Implements for India" was so great that a second edition of these publications had to be brought out during the year.

A pamphlet was also issued to advertise the sale of surplus dairy stock and was widely distributed.

V. Programme for 1918-19.

Major.

1. Practical treatment of pedigree dairy herd of Indian cattle and pedigree dairy herd of cross Montgomery-Ayrshire cattle.

II. Practical treatment of 1,200 acre mixed farm, with particular attention to profitable modern machinery and the financial result of the work.

The bulk of the produce of the Pusa farm is used for the maintenance of the dairy herd. The rotation adopted aims at the up-keep of the fertility of the land along with supply of concentrated food and long fodder and a constant supply of the green fodder throughout the year. Included in the above is the study on a practical scale of :—

(*a*) Rotations.
(*b*) Crops for fodder, seed and silage.
(*c*) Implements and machinery.
(*d*) Technique of cultural operations.
(*e*) Types of farm buildings.

III. *Experimental work at Pusa.* After the preliminary testing of the new experimental area at Pusa, the following will be started and continued along with existing work :—

(*a*) Rotational experiments.
(*b*) Trial of new varieties of existing crops, especially leguminous fodder crops, American maizes, foreign oats, and wheat varieties.
(*c*) Manurial experiments, especially seasonal and quantitative tests with phosphates.
(*d*) Rotation and manurial experiments already started.
(*e*) Seasonal tests with Java and Sumatrana indigo.
(*f*) Fermented green-manuring experiments in collaboration with the Imperial Agricultural Bacteriologist.
(*g*) Trial of sugarcane varieties suitable for growth without irrigation. (Some of Dr. Barber's varieties are very promising.)

IV. *Demonstrations, exhibitions and cattle sales of* surplus dairy stock, etc., will be held from time to time as occasion offers.

Minor.

V. *Touring and advisory.* Visits will be paid to provincial agricultural centres. This should tend to co-ordination of agricultural work.

VI. *Berseem cultivation.* Experiments with this will be continued.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(W. H. Harrison, D.Sc.)

I. Administration.

The Section was in charge of Mr. W. A. Davis, B.Sc., A.C.G.I., F.C.S., Indigo Research Chemist, until November 10th, 1917, on which date I took over charge as Imperial Agricultural Chemist.

Mr. J. Sen, Supernumerary Agricultural Chemist, continued on special duty under the Government of the United Provinces in connection with the work at the Ghazipur Opium Factory.

II. Education.

Mr. N. N. Ghosh and Mr. S. C. Dutt joined this Section as private students, the former on July 10th and the latter on September 9th, 1917, and both have since taken up appointments as assistants. Mr. A. K. Mitra joined the Section as a stipendiary student of the Bihar and Orissa Government on June 1st, 1918.

III. Meteorology and Drain-gauges.

The usual meteorological records were maintained and the crops and drainage waters from the drain-gauges were examined in the usual manner. The waters and crops from the Cawnpore gauges were also analysed.

IV. General analytical work and assistance given to other Sections.

The following samples were analysed and reported upon during the year :—

Soils	150
Feeding stuffs	155
Manures	22
Waters	31
Miscellaneous	9
Total	367

Amongst the manures examined was a sample of guano from the Nicobar Islands which contained 8·5 per cent. nitrogen.

A number of soils were received for examination from the Settlement Officer, Gorakhpur, consisting of various types of *bhat* and *bangar* soils. The analyses disclosed the fact that *bhat* soils are characterized by a high carbonate of lime content and could be classed as marls, whereas the proportion of lime in the *bangar* soils was low and they would be classed as loams. The *bhat* soils had a uniformally low available phosphoric acid (P_2O_5) content, whereas that of the *bangar* soils was about normal, although the total phosphoric acid present in both types was not dissimilar.

The following assistance was rendered to other Sections:—

Mycological Section. Six samples of soil from apple orchard soils and 21 samples from selected plots growing jute were analysed. The loss of copper sulphate during the steeping of jute seeds was determined.

Botanical Section. One "usar" soil was examined.

Agricultural Section. Eighteen samples of manures and 48 of sugarcane and feeding stuffs were analysed and reported upon.

Indigo Research Section. Seventy-three soils were analysed, consisting of samples from indigo soils of Bihar and samples from the experimental indigo plots of the Imperial Agricultural Bacteriologist. Three samples of cement and one of petrol were also examined.

Imperial Cotton Specialist. Fifty-one samples of cotton seeds were examined for their feeding value.

V. Methods of Analysis.

Dyer's method of estimating the available plant food in soils, or one of its many modifications, is adopted by

agricultural chemists throughout the world as a means of evaluating the manurial requirements of soils, and undoubtedly has proved of great value, but whether or not the method can be applied uniformly to all soils is a question which, since its introduction, has exercised the minds of chemists, and in particular a considerable controversy has arisen regarding the values obtained for available phosphoric acid in highly calcareous soils.

A short time ago Mr. Sen published the results of a series of experiments carried out in this laboratory, which showed that the addition of increasing proportions of carbonate of lime to a non-calcareous soil, rich in available phosphate, had the effect of greatly decreasing the values obtained, and that the values obtained when the calcium carbonate content reached about 20 per cent. were of the same order as those obtained from Pusa soils. An increase in the proportion of calcium carbonate over this value did not materially affect the values obtained.

The greatest change in the order of the values obtained occurred at the point where the calcium carbonate content was sufficient to neutralize fully the citric acid of the solvent solution, and Mr. Sen concluded that the effect of the calcium carbonate in giving rise to low available phosphate values was due to the neutralization of the acid. In addition, as the values obtained continued to decrease after the point of neutrality was reached, he concluded that a certain amount of phosphoric acid was "absorbed."

These experiments have been repeated in greater detail, and no evidence has been obtained that absorption occurs to any appreciable extent, but, on the contrary, the values obtained from the various mixtures appear to be determined mainly by the composition of the liquid after its reaction with calcium carbonate. With increasing amounts of calcium carbonate the composition of the liquid gradually changes, and the phases may approximately be defined as follows :—(*a*) 1 per cent. citric acid solution, (*b*) a saturated solution of calcium citrate with decreasing amounts of acidity, (*c*) a saturated solution of calcium citrate and

carbon dioxide, (*d*) a somewhat indefinite phase consisting of saturated solutions of calcium citrate with increasing concentrations of calcium bicarbonate, and (*e*) a final phase of a saturated solution of calcium citrate and calcium bicarbonate. Extractions of the soil in the absence of calcium carbonate with solutions approximating in composition to the phases defined above yielded values commensurate with those obtained from the corresponding mixture of carbonate of lime and soil. *Consequently the application of Dyer's method to calcareous soils is in effect an extraction with a series of dissimilar solutions the composition of which mainly depends upon the calcium carbonate content*, and this being the case, the values obtained in the case of calcareous soils of varying lime content can bear no very definite relationship one with the other and much less with non-calcareous soils. In the case of non-calcareous soils the value of Dyer's method is entirely due to a rigorous correlation of the analytical data with the known manurial reaction of specific soils, but such rigorous correlation is almost entirely lacking in regard to highly calcareous soils. The interpretation to be placed on the values obtained is very indefinite, and so long as this condition obtains the method must remain of dubious value.

Incidentally during the course of this investigation, it was discovered that the presence of calcium carbonate seriously interfered with the estimation of citrate-soluble phosphoric acid by the standard method under standard conditions. This is caused by the phosphate present in the ammonium citrate solution reacting with the calcium carbonate to produce insoluble calcium phosphate.

VI. Soils and Soil Conditions.

(*a*) **Paddy Soils.** The study of the relationship of the gaseous products of decomposition to these soils has been continued, and particularly that of carbon dioxide and hydrogen. It has been shown that carbon dioxide when present alone can persist as such, but that in admixture with hydrogen, and under biological influences, a recom-

bination occurs, of such intensity that the absence of any large quantity of these gases from the atmosphere in paddy soils is accounted for. Incidentally distinct evidence has been obtained to show that marsh gas can be produced by a combination of these two gases under biological influences.

This phenomenon offers a reasonable explanation to account for the accumulation of nitrogen gas in these soils without the necessity of putting forward the theory of the presence of peculiar types of fermentation, and it also has a considerable bearing on the question of lime conservation. The important fact has also been obtained that this reaction between carbon dioxide and hydrogen is not peculiar to paddy soils, but that it can be induced in dry soils with the utmost ease when the conditions are approximately anaerobic in character.

This investigation is practically completed and the results are being prepared for publication.

(*b*) **"Bara" Soils.** At the instance of the late Dr. Barnes, a series of pot-culture experiments were instituted with the object of testing the growth which could be induced in these sterile soils by washing out the salts present with ordinary water. The water used in this instance was the ordinary well water of Pusa with the result that germination was practically entirely inhibited.

The washed soils were, therefore, subjected to a careful examination, and it became evident that the bicarbonate of lime in the water had brought about a reaction leading to the production of alkaline carbonate in the soil. The soil experimented with originally contained a comparatively small amount of alkaline carbonate and a considerable proportion of sulphates and chlorides, whereas, after the washing process, the sulphates and chlorides were reduced in amount but the carbonate content had considerably increased, so that the effect had been to change the original condition of *white alkali* into one of *black alkali.*

The danger of *black alkali* forming in calcareous soils has recently been the subject of investigation in America,

but no attention has hitherto been drawn to the danger of employing a water containing calcium bicarbonate in solution for the irrigation of lands showing *white alkali*, and consequently this question is being subjected to a close investigation.

(*c*) **Mode of action of superphosphate in calcareous soils.** The mode of action of superphosphate in calcareous soils is somewhat obscure, and it appeared desirable to obtain information regarding the combinations formed, the rapidity of their formation, and the consequent effective range of superphosphate applications. With this object in view a preliminary series of experiments have been carried out in relation to the reactions occurring between phosphates of lime and calcium carbonate under varying conditions. It has been found that superphosphate reacts very rapidly at ordinary temperature with calcium carbonate ($CaCO_3$), the product of the reaction being the comparatively insoluble dicalcicphosphate, and that the latter in turn slowly reacts with more $CaCO_3$ forming tricalcicphosphate. At higher temperatures the intermediate stage practically disappears and tricalcicphosphate is formed with great rapidity.

The reaction between solid dicalcicphosphate and calcium carbonate ($CaCO_3$) in the presence of water is very slow owing to the slight solubility of the former, but as dicalcicphosphate is very rapidly removed by $CaCO_3$ from a saturated aqueous solution and also from a saturated solution in 1 per cent. ammonium citrate the probability of its persisting in solution in the presence of calcium carbonate ($CaCO_3$) is very remote.

Applying these facts to calcareous soils it would appear that the range of action of superphosphate is limited owing to the rapid formation of the comparatively insoluble dicalcicphosphate and the formation in turn of the insoluble tricalcicphosphate from any dicalcicphosphate which becomes soluble. The final stage in which the phosphoric acid (P_2O_5) is in the form of tricalcicphosphate would be quickly reached, so that the fertility of these calcareous soils

becomes largely a question of the solubility of this substance in the soil solution. These deductions are of considerable interest, and experiments are being conducted to test their validity.

VII. Crops.

(*a*) **Paddy.** A series of experiments were instituted with the object of determining whether or not the investigations on paddy on which I had been engaged at Coimbatore could be carried on in a satisfactory manner at Pusa. As a result there appears to be no insuperable difficulty to be faced, and consequently work on this crop will constitute in the future one of the major subjects of investigation of this Section.

For this preliminary work the question selected for investigation was whether or not the use of ammoniacal manures could be advantageously combined with green-manuring. For this purpose two series of fifty pots each were laid down, filled with soil to which graduated increments of ammonium sulphate were added, and to half of the pots green leaf manure was added at the rate of 10,000 lb. per acre. Into each series a selected pure strain of paddy seedlings was transplanted, and I am greatly indebted to the kindness of Mr. F. R. Parnell, Government Economic Botanist, Madras, for supplying me with the seed. At the time of writing the crops have not reached maturity and no quantitative results are available, but the growth in the pots is well differentiated and will, in all probability, give rise to definite conclusions. One point, however, is very clear even at this stage. The reaction of the two strains of paddy to green-manuring is very dissimilar and leads to the conclusion that the uncertain reaction of green manures is not entirely associated with soil conditions, but that the strain of paddy employed is a factor to be considered. This is a question which will require close investigation.

(*b*) **Tobacco.** The First Assistant, Mr. J. N. Mukerji, has continued his experiments on the effect of different

manures on the yield, quality, and nicotine content of Indian tobaccos. As regards yield the best results were obtained from farmyard manure, closely followed by a combination of superphosphate and potassium nitrate, whereas neither of the latter manures had any appreciable effect when used alone. The leaf produced from the various plots was submitted to the Director of the Indian Leaf Tobacco Development Company, Dalsing-Sarai, for valuation, and in his opinion no definite relationship was apparent between the manurial treatment given and the quality of leaf produced. Similarly no definite relationship was discovered in regard to the nicotine content.

The relative effect of *topping* and *spiking* the plant was also investigated. The yield of plant was practically identical, but the topped plants gave a greater outturn of stalk than the spiked ones. On the other hand, the topped plants yielded a leaf of better texture and a higher nicotine content.

An investigation contrasting the effect of rack-curing and ground-curing on the composition of the leaf showed that there is a destruction of starch and sugar during the process, but that ground-curing causes a greater reduction of the starch content than does rack-curing and at the same time produces a leaf of higher nicotine content.

(*c*) **Sugarcane.** For several years the effect of storing canes by clamping has been under investigation in the North-West Frontier Province, and the conclusion arrived at was that no deterioration of the juice took place. This has been confirmed during the last cold season, and, in addition, the effect of windrowing cane as practised in Louisiana has been examined.

The analytical values obtained were as follows :—

—	Ashy Mauritius Cane		Local Pounda Cane		
	Before windrowing	After windrowing for four months	Before windrowing	After windrowing for four months	
				Sample 1	Sample 2
Average weight of cane lb.	2·88	2·31	2·39	2·12	2·00
Juice . . per cent	74·86	72·73	75·84	71·70	72·00
Sucrose . . ,,	9·86	12·01	9·57	13·25	12·41
Glucose . . ,,	2·08	2·46	2·38	2·74	2·83
Brix . (cor.) ,,	13·69	16·69	13·34	18·05	17·17
Co-efficient of purity ,,	72·00	71·96	71·70	73·41	72·27

The effect of windrowing at low temperatures for a period of four months has been very marked. The weight of the individual canes decreases considerably, and this is accompanied by a decrease in the percentage of juice, showing that there has been a drying-up of the canes. This in turn has led to a concentration of the juice, but the purity of the juice tends to increase rather than to decrease, so that windrowing will not lead to the introduction of increased difficulties in the production of sugar.

The question whether or not windrowing leads to a loss of sugar is more difficult of solution, but an attempt was made to determine this by carefully checked weighings of the canes and juice produced. As a result it would appear that there is an actual loss, though comparatively small, in the case of Ashy Mauritius canes, but that in the case of Local Pounda there is a marked increase. This fact is of great importance and requires confirmation before being accepted, but if confirmed it opens out a field for further investigation.

VIII. Programme of Work.

Major subjects.

1. Continuation of the investigations into the amount and nature of drainage water from fallow land and land bearing crops.

2. Pot-culture experiments with paddy to determine (*a*) the relationship between rate of drainage and crop production, (*b*) the direct manurial value of the nitrogen in green manures, (*c*) the value of green manures when used in conjunction with nitrogenous mineral manures other than nitrates, and (*d*) the behaviour of different strains of paddy to green-manuring.

3. An investigation into the conditions governing the formation of *black alkali* in soils irrigated by calcareous waters.

4. Continuation of previous work in connection with the factors governing the composition and quality of tobacco.

5. The study of the effect of windrowing sugarcane at low temperatures.

Minor subjects.

1. A study of the mode of action of phosphatic manures in calcareous soils.

2. Checking the accuracy of the methods of analysis used at Pusa and the examination of new methods of analysis.

IX. List of Publications.

W. A. Davis . . Report on Agricultural Chemistry, 1916-17, for the Board of Scientific Advice.

REPORT OF THE IMPERIAL ECONOMIC BOTANISTS.

(A. Howard, C.I.E., and Gabrielle L. C. Howard, M.A.)

I. Introduction.

The Imperial Economic Botanist held charge of the Section during the year ending June 30th, 1918, with the exception of one month from September 8th, 1917, which was spent on privilege leave in India. During this period the Second Assistant, Maulvi Abdur Rahman Khan, was in charge of current duties at Pusa.

The work of the staff continues to be satisfactory. The Second Assistant, Maulvi Abdur Rahman Khan, has made himself exceedingly useful in carrying out a number of improvements in the Botanical Area and also in the experimental work at Indore, Bhopal and Gwalior. Chowdhury Ram Dhan Singh, Third Assistant, has worked well in connection with the experiments on indigo and on sub-soil aeration at Pusa. The Fourth Assistant, Babu Kashi Ram, has done useful work in connection with the vegetable-drying experiments at Quetta and with the tobacco-breeding experiments at Pusa.

The inadequacy of the facilities available at Pusa for making the most of the results obtained is becoming more evident as the years pass. The area of well-drained, well-aerated, high-lying, light land suitable for the testing and seed production of many of the crops under investigation, is exceedingly small. In consequence, the material available in the shape of pure lines cannot be worked through fast enough and even when this has been done, we have insufficient room to meet the ever-increasing demands for seed. New centres of distribution of Pusa wheats are springing up every year but there is never sufficient botanically pure seed for starting the work. What is urgently required is a special Institute of Plant Industry, situated in a more

favourable locality, to which the work of the present Botanical Section at Pusa can be transferred.

For the first time since the war, the transport of seed from the farms in Bihar has been interrupted due to the railway restrictions now in force. At harvest time, it was only possible to send seed to distant parts of India by passenger train. Such a method is out of the question in the case of hundreds of maunds of seed. Several important indents from Central India, Kathiawar and Bengal for this reason could not be met. The Bengal North-Western Railway, however, were able to provide sufficient transport for the wheat produced and distribution had to be confined to Bihar and the United Provinces. These difficulties were represented to the Central Transport and Foodstuffs Board with the suggestion that facilities should be given to the Agricultural Department generally in the transport of seed of all improved varieties of food grains intended for sowing. This has been accepted and the Directors of Civil Supplies have been instructed to issue priority certificates in class 2 (*b*) for all consignments of improved varieties of seed for sowing purposes booked by or under the order of the Agricultural Department.

II. Investigations at Pusa.

1. Wheat.

Substantial progress has been made during the year in the wheat investigations at Pusa both as regards seed distribution and also in connection with wheat breeding. Two of the early series—Pusa 4 and Pusa 12—are establishing themselves rapidly over large areas of the country as a result of the efforts of the Agricultural Departments. The rate of replacement of the country wheats by these improved types is now a question of organization, of the supply of seed and of adequate funds.

Pusa 12. The United Provinces are a long way ahead in the replacement of the mixed country wheats by an improved grade which also satisfies the cultivator on the important question of yield.

In the Central Circle of this Province, Mr. B. C. Burt has continued the systematic introduction of Pusa 12 on the alluvial soils of the Doab and Oudh portions of his charge. In connection with the special steps taken in conjunction with the Irrigation Department to increase the area under wheat, the bulk of the available seed supply was concentrated mainly in the Districts of Etawah and Cawnpore where the demand for this variety was intense. The total quantity of seed issued during the year from stores controlled by Mr. Burt was 12,290 maunds of which the largest items were Etawah 3,840 maunds, Cawnpore 4,773 maunds and the Sitapur Court of Wards 1,100 maunds. This variety is now well established in these Districts and is spreading rapidly (apart from the efforts of the Department) on account of the increased yield (estimated from crop-cutting experiments to be three to four maunds per acre under ordinary cultivation) and the enhanced price which it fetches. There are now many villages in the Etawah District and some in the Cawnpore District where practically no other wheat is grown and special measures are being taken to maintain these as centres of purity where seed can be purchased (to supplement the supply from the seed farms) and from which this variety will also spread naturally to surrounding villages. In the Sitapur District, most excellent work has been done by the Special Manager of the Court of Wards' estates, Mr. Dunne, in the systematic introduction of this wheat The Katesar estate now possesses its own seed store and last year supplied over a thousand maunds of seed to a group of neighbouring villages. The store worked at a considerable profit and inspection of the crops in the villages showed that they were practically pure. For the current year, this estate has stored 1,363 maunds, material quantities have also been kept by individual cultivators and arrangements are in progress for special demonstration plots and for the maintenance of pure stocks of seed on the areas commanded by three tube wells with which this estate is now equipped. It has unfortunately proved impossible to form even an

approximate estimate of the extent to which this wheat is spreading naturally in the Central Circle apart from direct departmental supplies of seed. Evidence is available that such natural expansion is very considerable but it is impossible to gauge its extent without a special enquiry for which staff is not available. From time to time, examples have been met with of seed being taken very considerable distances by relations of successful growers and of very considerable areas thus arising in tracts that had not been reached by direct demonstration.

In Oudh, Mr. L. C. Sharma continues to make rapid progress in establishing this variety where last year the estimated area under Pusa 12 was one hundred thousand acres. One of the chief agencies employed in seed growing and demonstration are the local notables, the Taluqdars of Oudh, many of whom are maintaining excellent seed farms. In one case, one of these farms supplied last year 2,000 maunds of pure Pusa 12 seed to the Agricultural Department of Bihar and Orissa and 1,100 maunds to the Central Circle. These figures convey some idea of the scale on which these private seed farms are being conducted and the useful purpose they are serving in the agricultural development of the country.

In the Western Circle of the United Provinces, Pusa 12 is now widely grown and has yielded well in the Agra and Meerut Divisions. Although the greater part of the produce is held in reserve in the villages for sowing, the indents received by the Agricultural Department show no signs of diminution. It is estimated that next *rabi* from ten to twelve thousand acres will be sown with seed controlled by the Officiating Deputy Director, Rai Sahib Ganga Pershad. The growers find Pusa 12 to be rust resistant, an early ripener, with a straw strong enough to resist high winds, and a higher yielder than the country wheats. It also requires less irrigation water and, as its grain is large and fine looking, it attracts the buyer immediately it is exposed for sale and so fetches a better price. When stored, it resists weevils better than the softer *deshi*. The fact

that it is beardless and the ears are copper-coloured when ripe enables this variety to be rogued easily and so kept pure by the cultivators.

The substitution of the country wheats by Pusa 12 in the United Provinces, important as this is, is, however, only a part of the advantage that is possible as a result of this work. One of the characteristics of a really superior variety is its power to respond to improved cultivation. The future possibilities of the plains of India in wheat production will be evident from a consideration of the yields obtained on the large scale during the past season with this variety. In Oudh, the average yield of Pusa 12 on large areas at Chandapur in the Rai Bareli District and at Malihabad near Lucknow worked out at 30 maunds per acre. At the Kalianpur seed farm near Cawnpore, which a few years ago was very indifferent village land, an area of over 70 acres gave an average of 27 maunds to the acre. Some of the cultivators' fields in the Etawah District weighed out over 24 maunds to the acre. At the Sugar Experiment Station at Shahjahanpur, the record yield of 35 maunds to the acre over 18 acres was reached. These yields are now the rule in well managed seed farms in this Province and are the result of a proper grading of the land combined with good cultivation and good management.

In Bihar, the introduction of Pusa 12 has made satisfactory progress in the Patna and Bhagalpur Divisions where, however, the work is still hampered by a shortage of seed. The whole of the Pusa 12 grown last year on the Dholi and other estates in North Bihar was placed at the disposal of Mr. Milne for use in South Bihar as well as an additional 2,000 maunds from Oudh. Even with the local supplies, these amounts only satisfied a very small portion of the demand.

In the Punjab, the Director of Agriculture reports that Pusa 12 is exceedingly popular in the Hoshiarpur, Jullundur, Gurdaspur and Sialkot Districts on well lands. The criticism has been made on this wheat that it is being

encouraged in these Districts without sufficient tests having been made as to its suitability for them. Feeling the force of these criticisms, the Director of Agriculture recently made a tour through these Districts and was struck by the great and unanimous enthusiasm evinced for Pusa 12 by all the growers of it. They all assured him that they got at least 25 per cent. increased outturn from it and a premium of at least 2 annas per maund. One grower sold 500 maunds of it to a Lahore contractor, who required it for eating purposes in that city, at a premium of 4 annas per maund over ordinary wheat. A certain amount of this wheat is also being grown in the Ferozepore, Karnal, Hissar and Rohtak Districts. Everywhere it is exceedingly popular and increasing amounts are being stored for next season by growers.

In Sind, Mr. Main has commenced the trial of Pusa 12 in various parts of the Province and the work is being continued. Some promising results were obtained in the Upper Sind Frontier District on zamindars' fields and the conclusion in this tract is that Pusa 12 is an early ripener and a heavy yielder. The zamindars concerned have kept the whole of the produce for sowing next season.

In the Simla Hill tracts, Mr. Peake has successfully introduced Pusa 12 in three villages in Sirmoor where this variety has done well. The people are very much taken with the grain and a number of villages have undertaken to grow nothing but Pusa 12 next year. The Chief Secretary of the Sirmoor State, Sirdar Narain Singh, who has interested himself in this work, has introduced a book to record the quantity of Pusa 12 sown each year together with the acreage. Distribution of seed will be carried out village by village so as to prevent admixture.

Pusa 4. In many parts of India where a rapidly maturing, high quality wheat is required which will also respond to good cultivation, Pusa 4 is meeting a distinct want and is rapidly coming into favour.

In North Bihar, the fall in the price of indigo led last year to a great demand for seed of this variety from the

indigo planters a portion only of which could be met. Nearly all the last crop of seed produced on the Dholi estate, an exceptionally fine product, was used for setting up a number of these estates with a pure supply of seed.

In the United Provinces, Mr. Burt reports that this variety has been a most marked success in the Ken and Dhasan Canal areas in the Districts of Banda and Hamirpur. Last year, over five thousand maunds of Pusa 4 were issued and in addition a number of zamindars and cultivators sowed considerable areas from their own seed. A large proportion of the seed was distributed through the Canal Department. At the last harvest, this variety fetched a very substantial premium in the local markets often amounting to eight to ten annas a maund over country wheat, the keenest buyers being exporters to Bombay. For the coming year, a stock of 8,000 maunds of this wheat is being held for issue in Bundelkhand. This variety is also likely to prove useful on the alluvium in helping to solve the fodder problem. For the third year in succession at Kalianpur, excellent crops of Pusa 4 have been obtained after early fodder *juar* (*A. Sorghum*). The practice, if generally adopted, would go far to solve the fodder difficulty in canal irrigated tracts and would permit of a larger area being put under wheat.

In the Central India States, the results obtained with Pusa 4 led to a keen demand for seed but nothing could be done to assist matters due to the railway restrictions in force. A supply was arranged for the Gwalior State but transport could not be obtained.

In the North-West Frontier Province, the result of the trials of this variety by the ryots is that " Pusa 4 has gained the cultivators' favour and has been accepted by them, and it is confidently expected that the vareity will occupy the greater part of the 280,000 acres of irrigated wheat in the North-West Frontier Province within a very few years. Pusa 4 has been so well received by the people that the North-West Frontier Province Government have allotted a sum of Rs. 25,000 to purchase seed from those

growers who tested the variety last season and a further sum of Rs. 25,000 has been set aside to build grain stores at some of the Tehsils in the Province, primarily to store seed of Pusa 4 for sale to the cultivators."

At the Sydney Royal Agricultural Show of 1917, Pusa 4 and two other varieties (Pusa 107 and Pusa 110), grown by Mr. J. B. Roach at Gilgandra in New South Wales, gained 44 out of 45 points and were awarded the first prize in one of the classes. At the Food Products Exhibition at Calcutta in January of this year, an exhibit of Pusa 4 and Pusa 12 and of bread made from Pusa 4, grown in Bundelkhand, gained a special prize. This exhibit was arranged in collaboration with Mr. Burt, all the wheat exhibited being grown on the farms of the Central Circle. The samples were particularly well grown and attracted much attention. The bread was baked by the Great Eastern Hotel Company from flour prepared by Messrs. Shaw Wallace & Co. at the Hooghly Flour Mills.

Punjab 11. In addition to the wheats selected at Pusa, one of the types, Punjab 11, separated by us at Lyallpur from a local mixture in 1906 and handed over to the Punjab Agricultural Department in 1908, is being distributed in the Canal Colonies of the Punjab, the area last year amounting to no less than 100,000 acres. This type will in all probability be rapidly displaced by Pusa 12 when the zamindars in the Chenab Colony cease to overwater their wheat. At Mirpurkhas in Sind, Pusa 12 has given as much as 25 maunds to the acre on the preliminary irrigation only, a result which confirms the common experience with this wheat in the United Provinces that it does best if somewhat sparingly watered.

Wheat breeding. The work on wheat breeding at Pusa, referred to in previous reports, is now rapidly approaching the stage when variety trials can be carried out on a field scale. Two of the selections (Pusa 32 and Pusa 42) from a cross made at Cambridge in 1910 between Pusa 4 and one of the new English wheats were tried last year by Mr. Burt at Kalianpur to see how these wheats would behave under

canal irrigation. The new types were tried against Cawnpore 13 and Pusa 12 on large plots and the sowings were made in duplicate. The yields obtained were as follows :—

TABLE I.

Trials of new Pusa wheats at Kalianpur.

Variety	Yields in lb. per acre		Remarks
	Grain	Straw	
Cawnpore 13	2,180	4,628	
Pusa 32	2,010	3,700	
Pusa 12	2,578	4,486	
Pusa 42	2,390	4,250	
Cawnpore 13	2,130	4,552	
Pusa 32	1,880	3,922	
Pusa 12	2,204	4,070	Damaged by lodging and by rats.
Pusa 42	2,320	4,538	

Nos. 32 and 42 have since been discarded as this cross has yielded six more wheats which are much more promising. These will be tried on a field scale at Kalianpur in October next. Three other series of crosses—on Pusa 6—are now rapidly becoming fixed and this material is expected both to yield wheats of immediate utility as well as parents for further crosses. To obtain the full advantage of the breeding work in progress at Pusa and to bring it to a practical issue several years' work will still be needed.

The results to India of the Pusa work on wheat were referred to in the House of Commons on August 14th, 1917, by Lord Henry Cavendish Bentinck (*Parliamentary Debates*, vol. 97, no. 116, p. 1008) when advocating that more money should be spent on research in agricultural development. It was pointed out that research is the basis of all progress in agriculture whether at home, in India or

in Africa, and that the money value of a single successful introduction like Pusa 12 is out of all proportion to the cost of a Research Institute.

2. Indigo.

The investigations on this crop, referred to in previous reports, have been continued during the year and have been confined largely to Java indigo. As this crop, when grown for leaf, is in the ground for nearly a year, it must be remembered that it differs entirely from the ordinary cold weather and monsoon crops as it has to maintain itself under a very wide range as regards soil conditions. Sown in September or early October, the first portion of the growth period takes place under cold weather conditions. The crop then has to survive the hot season when dry west winds are to be expected after which the temperature of the surface soil rapidly rises. The plant then completes its first year's growth in the monsoon phase, during the latter portion of which the aeration of the soil is interfered with by the cessation of drainage due either to the rise of the rivers, the flooding of the country, the rise in the subsoil water level or to a combination of these causes. In interpreting the results obtained with this crop, therefore, it will always be necessary to bear in mind these facts. It is generally in the second half of the monsoon and after the first cut has been taken that growth slows down and the plant often becomes diseased.

Much time has been spent in the investigation of the root system of this crop and the effect thereon of any alteration in the soil conditions and also of cutting back to varying degrees. The roots of Java indigo are exceedingly sensitive to undecayed organic matter such as oil cake, fresh *san* hemp (*Crotalaria juncea*) weeds or partially decayed indigo, particularly when these substances are added to the soil at times when the aeration is poor. It is then possible to kill the crop outright by these means. When, however, the damage does not proceed so far, the root system is often profoundly affected, the total absorbing

surface is reduced and the young roots and nodules lose their freshness and become discoloured and unhealthy. The above-ground portion ceases to grow normally and the young branches are frequently attacked by *Psylla*. Similar results have been obtained in the August sown seed crop when the indigo has been sown in land foul with weeds which have been turned under a few weeks previous to sowing.

The effect of complete or partial cutting back on the root system of rapidly-growing Java indigo has yielded some interesting results. In the cultivation of indigo in Bihar it is the universal practice to cut the indigo back completely in June and to leave the stumps for a second crop. The time taken in forming new shoots varies with the season. In very wet weather, sprouting is delayed and the process is distinctly favoured by a break in the rains. It has frequently been observed at Pusa that if a few leaves are left at the first cut, the new growth is much more rapid. This year, the effect of complete cutting back and of hard pruning on the root system was examined. It was found that complete cutting back, while the plant is in active growth, kills the fine roots and nodules and that a new absorbing system has to be produced before new shoots form. This naturally takes time. Heavy pruning, on the other hand, leads to far less damage to the roots and nodules, which at once explains the rapidity with which such plants form new growth. This fact may easily prove of considerable practical advantage to the indigo industry. If the crop could be grown in double lines with interculture, it could be heavily pruned at the first cut and the second crop could be advanced by several weeks. A new system of growing Java indigo, based on these results, has been worked out at Pusa. The crop is sown in September (after a clean fallow) in double lines with a space between for mechanical interculture to keep down weeds and to aerate the soil. The lines are pruned as early as possible after the rains break and the second cut is taken as soon as possible afterwards. Whether it will be better to be

content with this second cut and then dig out the stumps or to prune a second time and try to obtain a third and final cut, is a matter which further experience will decide. The results already obtained show that under actual field conditions in the monsoon the pruned plant, grown in double lines, shoots much faster and much better than the completely cut back plant. Further, it is possible in this way to keep the land clean by bullock cultivation during the *rabi* season and the following hot weather and to reduce the labour spent in weeding. As is well known, one of the great drawbacks at the present time of Java indigo cultivation in Bihar is the difficulty and expense of keeping down weeds.

The effect on the growth of Java indigo of an alteration in the soil conditions by the addition thereto of inert aerating agents such as sand or broken bricks and tiles, was investigated by means of the modified system of pot culture described in a paper read at the Indian Science Congress at Lahore.[1] As an example of the kind of results obtained by this method, the following measurements in the case of Java indigo may be cited :—

TABLE II.

The effect on the growth of Java indigo of diluting Pusa soil with potsherds or sand.

Kind of soil	No. of plants measured	Average length in cm.	Percentage increase
Soil only	33	36·7	0
Soil 1/2 + sand 1/2	36	51·6	40
Soil 9/10 + potsherds 1/10 . . .	33	48·3	31
Soil 7/10 + potsherds 3/10 . . .	35	50·9	38

The results obtained by diluting Pusa soil have been strikingly confirmed during the year by Mr. Clouston who

[1] *The Agricultural Journal of India,* Special Indian Science Congress Number, 1918, p. 36.

grew the same type of Java indigo under similar climatic conditions at two centres—on the stiff black soils at Tharsa and on the open, porous *bhata* soils at Chandkhuri near Raipur. On the well-aerated, poor *bhata* soils, Java indigo grew with great rapidity and formed good and abundant seed. On the richer but badly aerated black soils at Tharsa, the growth was very poor. These results are illustrated in a paper by Messrs. Clouston and Padmanabha Aiyer read at the Lahore meeting of the Indian Science Congress. A more effective confirmation of our views on the effect of soil aeration and drainage on the growth of Java indigo could hardly be desired. All interested in the welfare of the Bihar indigo industry should carefully study Messrs. Clouston and Aiyer's paper which is published in the Special Indian Science Congress Number of the *Agricultural Journal of India* of 1918. It will be interesting to see what class of colour will be obtained on these *bhata* soils when the Chandkhuri crop is made into indigo.

The results obtained on the production of seed of Java indigo under Bihar conditions were applied on a large scale during the year and very fine samples were obtained, much better than anything imported from Java. The yield was affected by shortage of moisture at the end of the rains and also by the dry winds during the ripening period in February which led to a good deal of loss from the splitting of the pods. For the first time since the shortage of seed of this crop became acute, the supply has been such that the price per maund has fallen very considerably, a result which will probably reduce the quantity of seed grown outside Bihar. The Pusa experiments have proved that good crops of seed can be obtained in Bihar provided the land is well selected and sufficient care is taken in the manuring, cultivation and spacing of the plants. The best returns are obtained under conditions of garden rather than of field cultivation, and it might easily pay some of the estates to devote very special attention to the seed crop on a small area and also to keep in reserve a year's supply in case of floods or unfavourable seasons. The experiments

on this subject are being continued as it is expected to raise, under conditions of intensive culture, heavy yields of seed no matter what the season may be. There is little doubt that the sooner North Bihar becomes self-supporting as regards Java seed the better. As the crop is not uniform but consists of a mass of heterozygotes, differing widely in root development, it is not safe to rely on seed produced under quite different soil conditions. The result of growing seed outside Bihar might easily result in a gradual change of type which might prove quite unsuitable to the local soil conditions.

The work on the selection of Java indigo is proceeding as rapidly as circumstances permit. One of the early selections, Type 15, is being grown on the large scale on four estates. A number of others are being tested on a field scale and reserves of seed are being accumulated. Java indigo is practically self-sterile and almost all the seed is obtained by means of cross-fertilization following insect visits. These facts render selection work very difficult and the multiplication of promising types very slow as only one kind can be grown for seed each year in the Botanical Area. This difficulty has been met to some extent by facilities granted by the proprietors and manager of the Dholi estate. A small field has been lent in one of the villages of this estate for indigo seed purposes and at the present time two types can be multiplied each year.

3. Tobacco.

The demand for seed of Type 28, both for cigarette purposes and also for general cultivation, continues to increase. In addition to a large number of small indents from all parts of India, three definite schemes of seed distribution have now developed—in North Bihar, in Burma and in the Central Circle of the United Provinces. Seed sufficient for 4,000 acres of new cultivation was distributed during the year. It is impossible to say how much locally grown seed of this type was sown.

In the Tirhut Division of North Bihar, the distribution of seed has been undertaken by the Indian Leaf

Tobacco Development Company who give out the seed to any one who applies for it. There is no obligation on the part of any ryot taking this seed to sell the produce to the Company. Mr. Acree, the Manager of the Dalsing-Sarai Branch, reports (Letter, dated April 13th, 1918) that the advantages obtained by the growers of Pusa seed can be summed up as follows :—

(*a*) Nearly all the seeds germinate.

(*b*) When transplanted, the tobacco plants are nearly all the same size and are equally strong. In consequence, very little replacement is necessary in the fields and partly for this reason a larger yield per *bigha* is obtained.

(*c*) At harvest time, the whole field is ripe and ready to cut at once. As a rule, when the ryot uses his own seed, several varieties are found in each field which come to maturity at different times and so cause the harvesting period to extend over four to six weeks. When this tobacco is ready for sale, the ryot has three or four sorts to dispose of instead of one uniform lot.

(*d*) Type 28 has not only been found very good for cigarette purposes but the growers also find no difficulty in disposing of it to the Indian dealers.

These results are interesting as showing that even the conservative tobacco grower, if given time, is able to appreciate the advantages of growing a pure line (which combines yield and quality) in place of the ordinary mixed crop. At first, the Company had some difficulty in getting the work started and the growers were averse to trying the new kind. Now all this is changed and should the demand go on increasing at the present rate, the difficulty will be to provide sufficient seed.

In Burma, seed for 800 acres has been supplied to Mr. McKerral for distribution in two of the most important tobacco-growing Districts.

In the United Provinces, Mr. B. C. Burt is distributing Type 28 among the tobacco growers of the Farrukhabad District where it is doing well.

As the production of large quantities of seed, true to type, of any variety of tobacco at an experiment station at which plant breeding work is also in progress, is a difficult and expensive matter, it would help materially if all future indents for seed could be sent in each year before the end of November. Small quantities of seed of Type 28 will always be available but special arrangements will have to be made if the demand for seed increases

4. Fibres.

The isolation of the numerous unit species which make up the gametic constitution of the four varieties of *Hibiscus Sabdariffa*, described in the Botanical Series of the *Memoirs of the Department of Agriculture in India* (vol. IV, no. 2), was continued during the year. When this is complete, it will be possible to finish the work and to put forward a full explanation of the results hitherto obtained.

Favourable reports continue to be received of the behaviour of the improved type of *patwa* (*Hibiscus cannabinus*) known as Type 3. Only a very small portion of the seed required could be supplied and none of the samples of fibre asked for could be prepared. About two acres of this type are being grown for seed during the present year for starting seed distribation centres in South Bihar and in Orissa. The seed likely to be obtained will not suffice for purposes of seed distribution in these areas but it is hoped thereby to stock a few farms at which this type can be multiplied for local seed distribution. Unfortunately, no suitable high land could be spared for fibre purposes. Only a few of the highest and lightest plots of the Botanical Area at Pusa are suitable for growing *patwa* to advantage and as similar conditions are required for a number of other crops under investigation, progress must

continue to be very slow in establishing the fibre of this improved variety as an article of commerce.

5. Oil seeds and gram.

The work on these crops at Pusa, referred to in previous reports, was almost at a standstill during the year due to the lack of suitable land for the culture work. The linseed cultures had to be grown on two new plots in the old fruit area which proved to be too uneven for such purposes. These cultures will be repeated if possible during the coming year.

6. Root development.

In a paper read before the Botanical Section of the Indian Science Congress at Bangalore in 1917, an account was given of the results obtained in the study of the root systems of the varieties of agricultural crops. It was suggested that this aspect of variety trials has been neglected in the past and that a study of the root systems of a set of types throws a considerable amount of light on the results of field experiments. During the past year, the work has been continued and further results have been obtained.

One of the difficulties in these investigations is to remove the soil so as to lay bare the distribution of the entire root system, including the finer branches. In the case of leguminous crops, it is also necessary to expose the nodules without damage. The best method so far found for use in fine, silt-like, alluvial soils, like those at Pusa, is to remove the soil by means of a knapsack sprayer. By this means, two plants can be dealt with in an ordinary working day and all the fine ramifications down to the piliferous layer and the root cap can be traced without damage. With leguminous plants, great care is necessary if all the nodules are to be obtained attached to the roots.

In soil aeration experiments, where it is necessary to study root development in relation to the physical condition of the soil, some method of growing a large number of

separate cultures has to be devised. Ordinary field plots are out of the question, due to the permanent alteration in the physical texture of the soil that would be involved. The ordinary pots used for culture work are also unsuitable for such investigations, for the following reasons :—

(*a*) There is inadequate space for root development, unless the pots are very large and deep.

(*b*) The normal circulation of air and water, such as occurs in the soil, is impossible in a culture pot even when unglazed and even when a sunk pot is used.

(*c*) Artificial drainage has to be provided in pots, which in itself acts as an aerating agent.

(*d*) Culture pots frequently introduce the temperature factor.

(*e*) Such cultures have to be constantly watered, an operation consumptive of much time.

(*f*) It is almost impossible to explore in detail the root system of a plant grown in a culture pot.

These difficulties can be overcome by using very small plots in the place of culture pots. Pits from three to six feet square are dug to the depth of two and a half feet, the upper nine inches of soil being kept separate from the sub-soil. Various aerating agents are mixed with the soil, which is then replaced, care being taken to refill the pits a little at a time and to compress the earth to the required degree. If prepared a few weeks in advance and irrigated immediately, the contents of the plots resemble very nearly the conditions obtaining in field culture. The difficulties connected with the circulation of air and water are in this way removed and the temperature factor does not interfere with the results. In cases where the soil is mixed with large quantities of aerating agents, such as potsherds, broken bricks, sand, or powdered charcoal, it is advisable to spread from half to an inch of ordinary soil on the surface of the beds to prevent any undue heating or cooling due to the higher conductivity of the aerating materials. Control plots of undisturbed soil and also of soil which has

been dug out and then re-filled should be included in the series. Where both root development and yield of seed have to be determined, the plots should be in duplicate as the removal of specimens for root examination introduces a new aeration factor.

The differences in growth and root development obtained by this modified form of pot culture are very striking and the new method has yielded results of considerable interest both at Pusa and also at Quetta. Measurements of the length of growth, of the total weight of crop and of the seed can rapidly be obtained while very useful results as regards the conditions on which root development depends have been secured.

III. Investigations in the Native States.

1. Central India States.

A beginning has been made in extending the investigations started at Pusa to some of the Native States. At the request of Mr. B. Coventry, C.I.E., Agricultural Adviser in Central India, and with the concurrence of the Durbars concerned, variety trials with wheat and gram were carried out on three of the farms in Central India during the past *rabi* season. Results of considerable value were obtained and the trials are being continued and extended.

The soils of Central India are by no means uniform and the conditions, even on a black soil tract like the Malwa plateau, vary considerably. On the well-irrigated, garden lands of Malwa, on which till recently opium poppy was grown, it has been found that Pusa 4 does exceedingly well and produces heavy crops under well irrigation. Mr. Coventry reports on these trials as follows (Letter dated April 13th, 1918) :—

"Pusa 4 has again been a great success this year on the irrigated area. Dhar, for example, has got 25 maunds per acre, a record result for Central India. I have therefore very strongly urged the Durbars to take up the distribution of this wheat on as large a scale as possible.

"I should like to add that when I came to Central India I was told by every one that the cultivators had been brought to the verge of ruin by the cessation of poppy cultivation and that what was wanted was a crop to replace opium. A good yield of opium is 9 seers an acre, which at Rs. 7 gives Rs. 63. Pusa 4 with a yield of only 15 maunds at Rs. 5 gives Rs. 75. The cost of production of wheat too is lower than poppy, the former taking three waterings at most, while the latter takes seven. The cultivators too declare that this wheat pays them better than poppy and they prefer it."

On the old poppy lands, Pusa 4 has passed the experimental stage and seed distribution is now in progress under Mr. Coventry's direction.

On the *barani* wheat areas of the plateau, however, Pusa 4 and similar types while producing good samples of grain have not shown any superiority over the local macaroni wheats. The contrast between the manner of growth of Pusa 4 on irrigated and on dry land was so great that it seemed certain that some other factor besides moisture was operative. On irrigated well lands, Pusa 4 tillers well, throws up tall, strong straw with long ears and large fine grain even better than that obtained on the Gangetic alluvium. The crop seems entirely at home and there is no trace of rust. On the dry areas, however, even after late rains and with abundant sub-soil moisture the ears are small, the straw weak and the crop easily lodges. The variety is hardly recognizable when grown under these conditions. These differences were found to be of a botanical nature and to be associated with root development. On the poppy lands under irrigation, the secondary roots develop well and the crop maintains itself largely on this system. Under *barani* conditions, practically no secondary roots are produced and the plant has to do its best on the primary system. Macaroni wheats when grown on the *barani* areas behave in the same way and rarely produce secondary roots, but here the first root system as well as the first internode are much more strongly developed

than those of bread wheats like Pusa 4. This difference is fundamental and it is clear that for the dry area of the Malwa plateau improved macaroni wheats are required. On the other hand, when these macaroni wheats are irrigated they do not respond to the changed conditions as Pusa 4 does and the extra moisture is as it were largely thrown away on these types.

These differences in root development indicate not only the general policy to be followed in wheat improvement on the Malwa plateau but also throw light on the methods of irrigation to be adopted for wheat. As regards the policy for these areas, high quality, rapidly maturing bread wheats which respond to irrigation and to improved soil conditions are clearly required for the well-irrigated lands. Improved macaroni types are needed for the *barani* tracts. With regard to irrigation, the first watering on all well lands should be given just when the plant is ready to tiller so that the formation of the secondary root system is not delayed too long. The secondary roots must follow the descending moisture and when these are established growth will proceed rapidly and the crop will be assured. Fortunately with well irrigation, the timing of the first irrigation is a simple matter.

Where the soils of the Central Indian States, as in parts of Gwalior, resemble the alluvium of the plains, it was found that wheats like Pusa 12 and Pusa 4 are quite suitable given a supply of irrigation water.

As would be expected from the root system, the Pusa varieties of gram, when tried on the various soils of Central India, provided no surprises. Many of the types did exceedingly well and it is expected in a short time to decide which is the best in all respects and to begin seed distribution.

Although these Central Indian trials have only extended over a single season and the work has had to be carried out either on new farms or on farms in the making, the results are much greater than could have been expected and the experience gained has been well worth the time and

trouble involved. For facilitating the trials at Indore and Bhopal we are indebted to Mr. Coventry, while at Gwalior, Mr. Higginbottom, the Director of Agriculture, and his staff placed the resources of the new farm at our disposal.

2. Kapurthala State.

At the request of His Highness the Maharajah, a visit was paid to the Kapurthala State in the Punjab with the object of suggesting the best means of developing the agricultural resources of the State. The main territories of this State comprise three well defined areas—the sandy high-lying areas (*dona*) near the town of Kapurthala, the low-lying inundated areas (*bet*) near the river Beas and the *ilâqua* of Phagwara (a portion of which is still in the original *dhak* forest) the agricultural conditions of which are similar to those of the adjoining Jullundur District. The Kapurthala State is the Eastern Punjab in miniature and the problems presented for solution apply in large measure to extensive areas of territory directly under British administration. The *dona* areas, given organic manure and water, can be made exceedingly fertile and here up-to-date large tube wells, provided with cheaply constructed permanent distributaries to prevent percolation, are a possible means of agricultural development. The low-lying *bet* lands present an interesting problem in drainage as well as for the distribution of varieties with a somewhat superficial root development. In Phagwara, the *dhak* areas provide an almost ideal surface for demonstrating the advantages of the realignment of holdings, the establishment of model villages and the provision of a complete system of surface drainage which at the same time will prevent erosion. A detailed report on these matters was submitted to His Highness who has decided, not only to start an Agricultural Department as soon as a suitable Director can be found, but to institute a State Development Fund for the smooth and rapid execution of any projects which are likely to improve his dominions.

IV. The Development of the Agriculture of Baluchistan.

The increase in the agricultural work carried out at the Fruit Experiment Station, Quetta, referred to in the last report continues. All the land available has now been taken up and no further expansion is possible with the means at present available. The extension of the vegetable-drying experiments has been rendered possible by means of a special grant of Rs. 1,500 from the Baluchistan Administration.

1. Soil aeration.

The decision of the Baluchistan Administration in 1911 to start a small experimental station near Quetta for the study of local questions has, in one direction, suggested far-reaching developments in Indian agriculture. In the Quetta valley, the texture of the soil is such that after surface flooding, ventilation is very easily impeded with disastrous results to the crops. The investigation of this matter led to the recognition of the importance of soil aeration as a factor in crop production and to the working out of an improved system of irrigation which, if adopted generally in India, would bring in every year an additional revenue of at least £5,000,000—enough to pay the interest on the war loan. Now that the investigation of the various aspects of soil aeration has reached a stage when the results can be summed up with advantage and their practical applications to Indian agriculture have become clear and definite, the present is a convenient opportunity for bringing together the various sides of this question and for emphasizing their importance in the future development of the country.

During the years 1912 to 1914, a number of observations and results had accumulated at Quetta which appeared to be most easily explained on the assumption that the stiff loess soils of the valley suffered from want of aeration and that in the removal of this factor lay the best line of advance. A similar explanation seemed to underlie numerous other

results and observations made in the plains of India and elsewhere. The available evidence in favour of this view was collected in 1914 and published in Pusa Bulletin 52 (*Soil ventilation*) in 1915. After this, further results rapidly accumulated which were dealt with in 1916 in Pusa Bulletin 61 (*Soil aeration in agriculture*). These two papers were very favourably reviewed in a large number of journals all over the world and many letters were received from correspondents dealing with the obvious explanation by the soil aeration factor of results hitherto obscure or but little understood. The publication of these views was the means of setting in motion a great deal of experimental work both in India and other countries. The connection between surface drainage, soil aeration and crop production and the increase in yield which follows the slightest improvement in surface drainage were dealt with in 1915 in Pusa Bulletin 53 (*Soil erosion and surface drainage*). Recently, more information has been obtained on this question which will be published when a convenient opportunity occurs.

During the past year, careful experiments have been conducted both at Pusa and at Quetta on the effect on the yield of the addition of inert materials such as potsherds and sand. In all cases, increased yields have been obtained both in the case of cereals and of leguminous crops. Some of the Pusa results are given in Table III.

TABLE III.

The effect of diluting Pusa soil with potsherds or sand.

1. Wheat, oats and tobacco.

Crop	Yield per acre of control plot	Yield per acre with one inch of potsherds	Increase per acre	Percentage increase
	m. s.	m. s.	m. s.	
Oats	24 17	28 36	4 19	18
Wheat	16 18	19 30	3 12	20
Tobacco . . .	21 0	23 3	2 3	10

2. Indigo.

Kind of soil	No. of plants measured	Average length in cm.	Percentage increase
Soil only	33	36·7	0
50% soil + 50% sand . . .	36	51·6	40
90% " + 10% potsherds . . .	33	48·3	31
70% " + 30% " . . .	35	50·9	38

Similar results have been obtained on the large scale on the Dholi estate in Bihar where in 1918 the best yield of Pusa 12 was given by the plot to which one inch of broken tiles had been added to the soil. At Quetta, the crop experimented on was lucerne. The increase due to the use of the various aerating materials is given in Table IV.

TABLE IV.

The effect of diluting Quetta soil with inert aerating materials.

Kind of soil	No. of plants	Yield of fresh produce	Percentage increase
		lb. oz.	
Soil only	33	12 2	0
2/3 soil + 1/3 potsherds . . .	33	15 0	24
1/2 soil + 1/2 wind-blown sand . .	33	17 2	42

That such results are possible can only be explained in one way, namely, that the aeration of both soils is defective. The increased yield is due to the increase in oxidation which follows the improvement in the porosity of the soil.

The existence of the soil aeration factor furnishes the explanation of the low yields of poor quality which always follow over irrigation on silt-like soils. The texture of these soils deteriorates after being flooded with water. As

the soil dries under the hot sun, the surface bakes into a hard crust largely impermeable to air. That the crust is impermeable can be seen by immersing in water a portion of the hardened surface soil after irrigation. The air escapes sideways not through the surface skin. Each successive irrigation destroys the soil texture more and more and the surface crust becomes more and more impermeable to air. The effect of irrigation on alluvial soils, therefore, interferes with its ventilation. The process removes one limiting factor, the want of water, but it introduces another, namely, the need of aeration. That this is so will be clear from Table V which contains the result of a recent experiment at Quetta.

TABLE V.

The introduction of a new limiting factor after irrigation.

Number of waterings	Area in acres	Total weight of produce	Total weight of grain	Yield grain per acre	Percentage reduction
		lb.	m. s.	m. s.	
One	3·99	10,367	52 6	13 2	0
Three	2·65	6,620	25 15	9 23	26

Here the last two irrigations reduced the yield through the introduction of another limiting factor—the need of soil aeration. Similar results[1] were obtained at three stations in the Punjab in 1917. One irrigation gave nearly ten maunds of wheat to the acre, two gave a little over sixteen, while three reduced the yield appreciably. These results prove that successful irrigation involves the working out of a practical compromise between the two conflicting factors —water and air. The aim of the irrigator is not the mere application of water *but the provision of water in such a*

[1] A full account of the irrigation results obtained at Quetta and elsewhere will be found in *Quetta Bulletins* 4 and 7 and in a paper on soil aeration in the *Indian Forester* of May, 1918.

manner as to interfere as little as possible with the aeration of the soil.

Confirmatory evidence of the importance of soil aeration in agriculture has been abundant in the recent literature. Experiments are in progress on this subject in India and other countries and a large number of further papers are expected to appear during the next two or three years. The opportunity was taken of the 1918 meeting of the Indian Science Congress at Lahore to place on record a statement of the present position of the investigations on soil aeration. This was done in the form of a joint lecture (with Mr. R. S. Hole,[1] Forest Botanist at Dehra Dun) to the whole Congress on January 9th last immediately after the presidential address. Mr. R. G. Allan, Principal of the Nagpur Agricultural College, supplemented the lecture by an account of his results on sub-soil aeration on the black soils. The lecture has since been published in full in the May issue of the *Indian Forester* and in the July issue of the *Agricultural Journal of India*. In the Botanical Section of the Science Congress, other papers on soil aeration were read and discussed including one by Mr. Clouston, Officiating Director of Agriculture of the Central Provinces, and Mr. A. R. Padmanabha Aiyer, Officiating Agricultural Chemist, Central Provinces, on the results obtained on the poor laterite soils (*bhata*) at Chandkhuri near Raipur. Hitherto, these soils (of which there are millions of acres now lying practically waste or in jungle) have only borne occasional crops of inferior millets in the rains and have been considered useless for agricultural purposes. In reality, however, they possess in their porosity and good drainage, enormous potentialities which Mr. Clouston is now developing. The aeration of the *bhata* soils is perfect and with the addition of organic manure and irrigation water very fine crops of cotton, indigo, groundnuts, sugarcane and various fodders have been obtained. One feature of these crops is

[1] Mr. Hole's investigations on soil aeration deal with the importance of this factor in various forestry and ecological problems. His conclusions have been arrived at largely from physiological experiments and agree with our own on the importance of the soil aeration factor in plant growth.

their remarkable freedom from disease compared with those grown under similar conditions on the richer but poorly aerated black soils. Messrs. Clouston and Aiyer concluded their paper as follows :—

"We venture to say here that Mr. and Mrs. Howard of Pusa and Mr. Hole of Dehra Dun have done India a great service in focussing our attention on the importance of drainage and soil aeration as soil factors which count for even more in crop-production than manuring. The time may yet come when, with the extension of irrigation facilities, these laterite soils, which in the Central Provinces at least are at present considered to be below the margin of cultivation in most cases, will be treated as garden land of the best quality. Given water, all that is required for such soils is cultivation and manure. We can rely on the nitrifying organisms to do the rest."

2. The improvement of fodder production.

Progress continues to be made at Quetta in the study of the various factors involved in the growth of leguminous crops and also in the better preparation and utilization of the resulting fodder.

One of the factors concerned in the raising of these crops has been proved to be the aeration of the soil. That such a result was probable could be inferred from the following facts :—

(*a*) In both *shaftal* (*Trifolium resupinatum*) and lucerne cultivation, the edge effect is pronounced and the crop is always better on the small embankments separating the irrigation compartments (*kiari*) than in the *kiari* itself.

(*b*) In order to maintain a good stand of lucerne under Quetta conditions it is necessary to manure the land every winter with farmyard manure applied on the surface.

(*c*) The best crops of lucerne are obtained by leaving the mulch of manure undisturbed during the growth period as by this means the surface soil

remains open and a crust cannot form. Surface cultivation by mixing the mulch of manure with the soil allows a crust to form after irrigation and the yield is considerably reduced.

(*d*) The number of cuts obtained from a *shaftal* crop, other things being equal, depends on the presence of aerating materials in the soil.

The importance of soil aeration in the growing of these crops was confirmed during the year by the results of a series of aeration experiments with lucerne and *shaftal*. The origin of these experiments is a matter of some interest. In 1917, during a visit to the Mustung valley in the Kalat State, the great difference between the health and vigour of the wheat and other crops near Mustung compared with those in the Quetta valley was very marked. The difference appeared to be due to the admixture of the Mustung soil with fine wind-blown sand carried into the valley from the desert to the west. Samples of this wind-blown sand were obtained and cultures were started of mixtures of Quetta soil and various aerating agents including this desert sand. The results obtained were very striking. An admixture of 50 per cent. of the wind-blown sand to Quetta soil increased the yield of lucerne by 42 per cent. These experiments are being continued and will be published in due course. The improvement in the physical texture of the soil of the Mustung valley brought about by this wind-blown sand would also explain the reputation for quality this locality has achieved in such crops as wheat, tobacco and melons. The admixture with sand improves the aeration of the soil and this in turn influences the development of quality. One possible means of improving the Quetta soil would be by the admixture of finely ground ashes which are available in large quantities near the railway station. Some of this waste product is being ground up in a mortar mill and will be applied to the land this year. For vegetables and crops like lucerne, ground ashes might act as a very useful manure.

The trials of baled *shaftal* by the Army at Quetta, which were referred to in the last report, were duly completed and

the results were reported to Army Headquarters. Orders have since been received for carrying out a further set of tests on a larger scale and for this purpose about 1,000 maunds of baled clover have this year been supplied for the trials supervised by Brigadier-General Cook, R. G. A. This fodder was grown by the zamindars near Harnai and was purchased green for drying and baling. These operations were interfered with to some extent by the scarcity and dearness of agricultural labour which resulted from the temporary concentration of troops at Harnai and in the neighbourhood in connection with the Mari Field Force. Some of the fodder was supplied to the troops green, the rest was dried and made into bales for the tests at Quetta. These are now in progress and are proceeding satisfactorily. A suitable centre for the growth and baling of *shaftal*, lucerne and berseem on the large scale has been found at which it will be possible to erect and run a hydraulic press. Detailed suggestions as to future work are being drawn up at the request of the Army authorities.

At the suggestion of Brigadier-General Cook, R.G.A., and with the assistance of Major Hislop, experiments have been made at Quetta to determine whether or not these leguminous fodders could be baled close enough to meet Army transport requirements. The difficulty in baling *shaftal* and lucerne hay, under the dry conditions at Quetta, is to obtain a close bale without, at the same time, damaging the product. Both these fodders dry out so quickly and become so brittle that it is almost impossible to bale them without considerable loss of leaf—the most nutritious portion of the fodder.

These difficulties have now been overcome. If *shaftal* or lucerne hay is allowed to dry outright in small stacks, the brittle fodder can be got back into condition for close pressing by watering the heap on the outside by means of an ordinary watering can and by covering it up for 24 hours with a tarpaulin or a small tent. The moisture then penetrates the heap and brings the fodder into condition for handling and baling. The outside layers are often a little too damp,

but if these are allowed to dry in the sun for an hour or so, the extra moisture rapidly evaporates. The amount of water required is about 10 gallons for every 150 cubic feet of stacked fodder. To enable the moisture to spread evenly, heaps $14' \times 3{\cdot}5' \times 3'$ are quite suitable. Some judgment is required in baling the moistened fodder but a little practice will avoid any danger of pressing too damp. The best stage is when the fodder is just beginning to feel brittle.

The baling experiments were duly carried out on August 1st, 1917, by means of the Boomer press at the Supply Reserve Depôt, Quetta, with lucerne brought into condition by damping as indicated above. Two kinds of bales were made with the Boomer press—(1) with lucerne only and (2) with chaffed lucerne and *bhusa* in equal parts by weight mixed ready for feeding. The lucerne by itself was found to be the more easily compressed. The size of a maund bale of lucerne was $30'' \times 16'' \times 13''$ (equivalent to 97 cubic feet to the ton). The size of the mixed lucerne and *bhusa* bale was $31'' \times 17'' \times 13''$ (equivalent to 105 cubic feet to the ton). The press had not been used for some time and was a little out of adjustment or it would have been easy to compress to 90 cubic feet to the ton—the Army standard for pressed *bhusa*. There is no doubt therefore that these leguminous fodders can be compressed to the required degree.

As regards keeping qualities, there is every reason to believe that no danger need be apprehended from this source. Several bales, made on August 1st, 1917, were opened during the present year and the fodder in both the lucerne and mixed bales was found to be in perfect condition with no trace of sourness or mouldiness.

Now that all the difficulties in converting these leguminous fodders from the green state into compact bales of hay have been solved and many successful trials of the product have been carried out, it only remains to suggest the desirability of taking up similar work in localities such as the Punjab, the Western Districts of the United Provinces and Central India where some or all of these crops are easily raised. A stock of such concentrated fodder would be of

the greatest use in India for improving the feeding value and palatability of existing materials such as *bhusa*, *karbi* and dried grass both for ordinary stock, for oxen engaged in transport and also for dairy cows and buffaloes.

Lucerne behaves as a perennial both on the soils of the Peninsula and also on those of the alluvium wherever the drainage and soil aeration during the monsoon period are sufficient. When kept free from weeds, when well manured and supplied with sufficient moisture, large crops are obtained. Berseem does well during the cold season in localities like Sind and the Central Provinces where the temperature and soil conditions are suitable. *Shaftal* does best on the upland frontier valleys but it can also be grown to advantage in the Punjab. In some localities, all three of these crops can be grown and in this way a large number of cuts of fodder could be produced for making into hay.

3. The sun-drying of vegetables.

The preliminary work connected with the sun-drying of vegetables at Quetta, referred to in the last report, has aroused a considerable amount of interest throughout India and numerous requests for these products have been received. In order to discover the extent of the demand for sun-dried vegetables from the civil population, an exhibit of this material was arranged for at the All-India Food Products Exhibition at Calcutta in January of the present year. By this means we were enabled to get into touch with a number of possible consumers including some of the lines of steamers based on Calcutta. There is likely to be a demand for sun-dried vegetables from hotels and boarding houses, clubs, private individuals in Southern India, expeditions, passenger steamers, sailing ships, engineering parties engaged in railway construction, bridge building and on oil-fields, and also from the caravans on the trade routes in desert regions like Persia and Seistan. A number of samples have been tested by various people and very favourable reports have been received. The Calcutta exhibit, for which a special prize was awarded, was then transferred to Lahore

and shown at the Conversazione in connection with the meeting of the Indian Science Congress. This attracted many visitors and completely exhausted the first edition of Bulletin No. 8 in which the process of sun-drying is described in detail. A paper on this subject was read and discussed in the Botanical Section of the Science Congress.[1] The medical men present were keenly interested in this matter and as a result of the discussions we secured the co-operation of Colonel Sir Leonard Rogers, F.R.S., in the investigation of the anti-scorbutic and anti-berri berri properties of vegetables prepared in this manner. A number of samples have since been despatched to Calcutta for these experiments.

As the only way of finding the value of a new thing is to sell it, arrangements have been made to place sun-dried vegetables on the market. Suitable agencies have been arranged at Calcutta, Bombay and at Quetta and as soon as the coloured labels (which are being designed and printed by the Lucknow School of Arts and Crafts) arrive, half pound tins of these vegetables, in a compressed form, can be purchased by the public. The price charged will be below that of the Californian tinned product which is put up wet and which is very heavy and bulky to transport. Samples of dried vegetables, in brick form, will also be available this year for trial on the trade routes in Seistan and Persia.

The quality of sun-dried vegetables depends on the way in which the fresh product is grown. Most of the vegetables produced for the market at Quetta are not well cultivated and in almost all cases about half the irrigation water is wasted. The result is that the fresh material now available is not the best possible for sun-drying and the yield is somewhat low. The methods of vegetable growing in this locality appear to be capable of considerable improvement and arrangements have been made to grow a plot at the Fruit Experiment Station in 1919 and to work out the best methods applicable to local conditions. At the same time,

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[1] "Sun-drying of vegetables." *The Agricultural Journal of India*, vol. XIII, pt. IV, 1918.

the cost of conversion on the large scale can be determined with the help of labour saving devices such as slicing and peeling machines which are being imported for the purpose. As far as can be seen at present, there is every prospect of a new and profitable industry being created in Baluchistan in the growing of vegetables for sun-drying.

For military purposes, the Army at Quetta is continuing the work started in 1917 and during the present year it is expected that a further quantity of sun-dried vegetables will be prepared for use on active service.

The demand for copies of Bulletin No. 8, in which the process of sun-drying was described, has been considerable. The first edition, printed in August 1917, became exhausted early in the present year and a second English edition was brought out in March 1918 as well as one in Urdu.

4. The improvement of fruit culture.

In the last report, reference was made to the results obtained in the raising of nursery stock for local distribution. These matters have since been described in detail in Bulletin No. 9, which was issued early in the present year. A considerable number of copies have also been sold and distributed in India.

The demand for fruit trees still continues very great and every year many small trees are purchased for planting which really ought to remain another year in the nurseries. It is hoped now to hold in reserve sufficient trees for a second year's growth for issue in the autumn of 1919. As all the details relating to the experiments on the propagation of fruit trees have been published, it would seem that the time has come for private enterprise to begin the supply of the large number of trees required every year in Baluchistan. The ideal arrangement in this matter would appear to be for Government to supply a reasonable number of trees every year, to maintain suitable varieties true to name, to provide budwood, to train *malis*, to undertake all the importation of new varieties and to carry out all experimental work in these matters. After this, private enterprise should supply any

further trees needed and should supplement the work of the experiment station. Unless some such principle is adopted and means are found of developing local agencies to take over portions of the work when it has passed the experimental stage, the burden of routine will become so great that no further investigations will be possible. Fortunately, a beginning has already been made in this direction and two private nurseries have been started at Quetta by retired Europeans. The work is not arduous and when carefully carried out should prove both interesting and remunerative. One of the surest means of increasing the income of a private garden at Quetta is by raising a number of young trees for sale every year. Similar work might also be taken up in the districts.

5. Fruit packing.

The sale of improved fruit boxes to the public, which up to 1916 had proceeded very satisfactorily, has latterly been greatly interfered with by the war. Although arrangements were made in 1916 for the delivery the next year of a large supply of cardboard boxes, punnets and crate wood, all the consignments were delayed and arrived at Quetta too late. The consignments of cardboard boxes and punnets from Great Britain happened to be shipped to India by the same vessel which struck a mine outside Bombay and only just reached port. In due course, both consignments arrived at Quetta at the end of the fruit season. The crate wood was arranged for in 1916 from two Indian factories but in each case delivery did not take place till the middle of 1918 due to the fact that both the saw mills were engaged in war work. At the time of writing, July 24th, 1918, the last of the consignments ordered in 1916 has arrived at Quetta and the various boxes and crates can now be put together. It was hoped that the box boards prepared in India from locally grown timber would be considerably cheaper than similar supplies from Norway, Great Britain and Japan but this expectation has not been realized. Indian boards have proved inferior to and considerably

dearer than imported material, while the railway freights now charged for full waggon loads are enormous. Till more normal conditions of supply and transport obtain and till importation from Norway and other countries is again practicable, it will scarcely be possible to collect any more fruit box material at Quetta. The supplies already in hand are expected to last till 1920 after which no more orders will be sent till after the war. This work is financed by means of Treasury advances and purchases and sales have to balance each other. The system therefore does not admit of the holding of large stocks of unsold materials and is quite unsuited to the trade conditions of the present time. As soon as the war is over and prices settle down, the supply of these boxes will be handed over to a local agency. The demand is now considerable and the suitability of the various boxes and crates has been thoroughly tested. Railway concessions have been arranged for and are now in working order. The whole question has passed the experimental stage and will be dealt with by the trade at the earliest opportunity.

V. Programme and Publications.

1. Programme of work for 1918-19.

Investigations will be continued on the following crops on the lines indicated in the annual reports and in the publications of the Section—wheat, tobacco, fibre plants, indigo, gram, oil seeds, fodder crops and fruit.

2. List of Publications.

The following papers were published during the year :—

1. The sun-drying of vegetables. *Bulletin* 8, *Fruit Experiment Station, Quetta.* First edition, August, 1917. Second edition, March, 1918. Abstract read at the Indian Science Congress, Lahore, 1918, and published in the *Agricultural Journal of India*, vol. XIII, pt. IV, 1918.
2. Tarkarion ka dhup men khushk karna. *Rasala no. 8*, August, 1917. (Urdu publication.)

3. Note on the baling of *shaftal* and lucerne hay. *Journal of Dairying and Dairy Farming in India,* vol. V, 1917, p. 61. Reprinted in the *Agricultural Journal of India,* vol. XIII, pt. IV, 1918.
4. The agricultural development of North-West India. *Journal of Dairying and Dairy Farming in India,* vol. V, 1917, p. 7.
5. The improvement of fruit culture in Baluchistan. *Bulletin 9, Fruit Experiment Station, Quetta,* February, 1918.
6. Recent investigations on soil aeration. A lecture with Mr. R. S. Hole, delivered to the Indian Science Congress, Lahore, 1918, and published in full in the *Indian Forester,* vol. XLIV, 1918, p. 107. Reprinted in the *Agricultural Journal of India,* July, 1918.
7. Report for 1916-17, on Economic Botany for the Board of Scientific Advice.
8. Some methods suitable for the study of root development. A paper read at the Indian Science Congress, Lahore, 1918, and published in the Special Science Congress Number of the *Agricultural Journal of India,* 1918.

REPORT OF THE IMPERIAL MYCOLOGIST.

(F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S.)

I. Charge and Establishment.

Dr. Butler held charge of the Section throughout the year and I remained as Second Imperial Mycologist. On 8th July, 1918, Dr. Butler proceeded on deputation to the Federated Malay States and handed over charge of the office to me, hence I am writing this report. It is with deep regret that I have to record the death, on 1st March, 1918, of Munshi Inayet Khan, Third Assistant to the Imperial Mycologist. Munshi Inayet Khan was the oldest assistant in the Section and had been with Dr. Butler from its commencement; his record of service was, however, considerably longer as he served with Mr. Duthie in the Botanical Survey of India and held the Hazara (1888), Relief of Chitral (1895), Punjab Frontier (1897-98), and Tirah (1897-98) medals for plant collecting service on these expeditions. Of late years he held charge of the mycological herbarium at Pusa and the accurate knowledge of systematic botany, which he had acquired by many years of practical experience, was always of the greatest utility in the work of the laboratory; in this direction his loss is one which we can hardly hope to replace. Throughout his service he remained an example of loyalty and efficiency to all his fellows.

II. Training.

Lala Kripa Ram, L.Ag., Assistant to the Economic Botanist, Punjab, finished his course of training on 25th September, 1917. Mr. B. N. Vakil, a private student, worked in the Section from 19th November, 1917 to 29th June, 1918. Mr. M. Mitra joined the Section on 15th June, 1918.

III. Diseases of Plants.

The investigation and the demonstration of methods of control of plant diseases formed as usual the major part of

the work of the Section. Crop parasites were collected and identified and advice given to the officers of the Department and the general public as occasion required.

(1) Ufra of rice. Evidence was obtained both in pot cultures at Pusa and in a field experiment carried out in collaboration with the Bengal Department on Dacca farm that this disease can be sometimes conveyed by seed from an infected crop.

The laboratory work at Pusa during the past season was directed chiefly to a study of the conditions which enable or induce the parasitic eelworm (*Tylenchus angustus* Butl.) to leave the water of the paddy fields and ascend the plant to reach its susceptible portion near the apex of the shoot. In last year's report it was explained that atmospheric humidity immediately around the plant was the determining factor, the worm being unable to move out of water except at high humidities.

The exact measure of the humidity of the air on the surface of a plant is exceedingly difficult. It is, however, possible to grow paddy in enclosed chambers and measure the relative humidity of the air within the chamber. It is also possible to watch the movements of worms on glass slides kept in similar chambers. By these methods, using a Polymeter, it was found that the worms can move freely when kept on glass slides at a relative humidity of 95 (temperature 87° to 90° F.), but not at all at 90, the exact point being apparently near 93. On the living plant they can move at lower air humidities, certainly below 90 but not at 75, at the same temperature. If they can soon reach the inner folds of the shoot (which is only possible in young seedlings), they become less dependent on high air humidity than when they remain on the exposed surface, no doubt because the vapour of transpiration causes the confined air within the folds to reach a higher degree of saturation than that of the surface.

Temperature also influences movement but less regularly. For instance, worms when free in water are much

more sluggish at 73° than at 88° F. provided they have not fed recently, but active, well-nourished worms taken directly after feeding show little difference in motility at the two temperatures. At low temperatures there is ordinarily little tendency to ascend shoots projecting out of the water even when the air is approximating to saturation, but here again freshly fed worms seem somewhat more active than those that have been dried for some time.

Light is also a factory but the results so far obtained require further testing.

Starvation is a factor of great importance. In one experiment two batches of 20 worms were placed in drops of water on slides in a saturated atmosphere, one batch containing only worms that had not fed for 18 days, the other worms taken after they had had access to living young paddy shoots. In 24 hours all but 4 of the former batch had left the water and were wandering freely in the chamber, whereas in the other batch none had left the drop. Four days later only 1 was left in the first drop while 19 were still in the second.

Hence amongst the factors which control the wanderings of the worm in search of the food that it can only obtain from the living paddy plant, some, such as humidity, are absolute in that they impose conditions which rigidly limit the power to move, while others are relative in that they act through the instinctive or other vital processes of the worm and so influence its movements indirectly, and are more variable in their action.

In carrying out such enquiries progress is necessarily slow, since the period during which the work can be done is limited each year, and all the work has to be done under microscopic control, the worm being invisible to the naked eye.

As an indication of their practical application, it is sufficient to mention that in certain districts the earliest attacks take place on the *aus* paddy growing in close proximity to or even mixed with the main crop, and that as the

former ripens off about July it becomes unable to supply food to the worm : the latter must then rapidly fall into the starvation condition which will induce it to wander vigorously to the *aman* crop.

Some further progress has been made in defining the limits of the infected tract. No new outbreak outside previously known areas was reported during the year except a small extension towards Chittagong. Two fieldmen from Pusa examined the infected areas near Chittagong, in Faridpur, and in the Manikganj Subdivision of Dacca.

The following demonstrations were carried out by the Bengal Department of Agriculture under advice from Pusa.

Dacca District. (*i*) *Vikrampur.* About 58 acres were treated by burning the stubble and sown with either *aman* or *digha* paddy alone or with *aus* and *aman* mixed or with *aus* followed by jute. The *aus* paddy escaped, the *digha* was very slightly damaged, but about 12 acres of *aman* were attacked. The amount of loss was not reported.

(*ii*) *Nagari.* About 25 acres were treated as above. Ufra appeared in 3 acres only but the amount of damage was not reported.

(*iii*) *Pubail.* A small isolated block which has given little or no crop for several years was treated as before. The disease appeared in one part only. The yield was about seven-eighths of a normal crop for the first time for a number of years. Another larger area was similarly treated but the loss was about a quarter of the crop. It was not isolated from untreated infected paddy close by.

Faridpur District. About 10 acres were treated as above at Gopalganj. No disease appeared until late in the year. Further reports have not been received.

A detailed account of the present state of knowledge of the disease has been written by Dr. Butler and it is hoped will be published during the coming year.

(2) Black band disease of jute. During the rains of 1917 an area of about 40 acres of jute (*Corchorus capsu-*

laris) was grown on the Pusa farm as a seed crop for the Fibre Expert to the Government of Bengal. The variety grown was that called *kakya bombai* and about half the area was sown in March and the remainder in June. The early sown portion of the crop grew well, but about the beginning of August a number of plants appeared to be drying up, the leaves falling to the ground and the stems blackening. Inspection of the crop showed that this disease commenced with the formation of a black patch on the stem at a point from 1½—3 feet above the ground level. This black patch spreads rapidly forming a discoloured band round the stem about 4—12 inches long. At this stage the leaves of the plant droop and fall and the black band extends up and down the stem, until finally the diseased plant is left simply as a blackened stick.

Examination of the surface of a diseased stem showed the presence of large numbers of pycnidia of a fungus which proved to be identical with that known as *Diplodia Corchori* Syd. This fungus was first collected as a parasite of jute on Pusa farm in 1910, but until the present season there was no reason for suspecting it of being more than an occasional parasite. As, however, the crop ripened the disease increased until it was estimated that about 20 per cent. of the crop was infected. The fungus was obtained in pure culture and inoculations upon healthy plants succeeded in establishing the disease and proved the parasitism of the fungus.

Inspection of the jute seed crop in other parts of Bihar showed that the disease was in 1917 widespread and, as the Bihar seed crop was intended for seed distribution in the jute growing districts of Bengal, suggested the advisability of disinfecting this seed before sending it to Bengal. The fact, however, that an examination of old specimens of jute in the mycological herbarium at Pusa showed that this fungus had, during the past 10 years, been collected, but not identified nor suspected of parasitism, over a large area in Bengal, indicated that there was no danger of introducing

a fresh parasite to the jute growing districts. Nevertheless as the seed was being distributed very extensively by the Bengal Department of Agriculture, it was decided to disinfect it. The problem of disinfecting the jute seed resolved itself into discovering some method of treatment which would kill those spores of the fungus which became mixed with the seed during threshing without injuring the germination of the seed. Experiment showed that steeping for 10 minutes in a 2 per cent. solution of copper sulphate could be relied upon to inhibit the germination of the fungus spores without appreciably affecting that of the seed. The whole of the Bihar seed crop was therefore collected in Pusa and steeped in a 2 per cent. solution of copper sulphate for 10 minutes and the seed then carefully dried on a concrete threshing floor. The work was carried out during the first three weeks of January and the seed at once bagged and despatched to Dacca, a total of about 20 tons of seed was treated in this way.

Early in November the jute seed crop in Kamrup was inspected and found to be suffering from *Diplodia Corchori*. This seed was collected and treated at Dacca. A fact which was apparent both in Bihar and Kamrup was that the late sown crop was relatively immune from attack. All field observations suggest that in some way the incidence of the disease is dependent upon the host plant reaching a certain stage of maturity and size and thickness of stem. Field and laboratory experiments are being continued at Pusa with the object of elucidating the conditions which favour the spread of the disease and any further methods of control. Further observations and experiments on *Rhizoctonia* on jute and its relation to this new disease are also being made; this investigation is being carried out by Dr. Shaw.

(3) Root rot of the sal tree. The inoculations carried out at Dehra Dun on young sál trees have not yielded any results, and a further series of infections using pieces of fresh sporophores of *Polyporus Shoreæ*, is being arranged in collaboration with the Forest Botanist. The figures

obtained during the past year in the fungus observation plots at Rajabhatkhawa show a number of new attacks but a relatively low proportion of fresh deaths.

(4) Black thread disease of rubber. In Burma there is now hardly a plantation in bearing that is free from the effects of this disease. It is not confined to the tapping surface and the fruits as previously supposed, but it attacks leaves as well and causes an extensive defoliation. The infected trees do not readily recover from the effects of leaf-fall and consequently there is a great reduction in the yield of latex in the months of October, November and December when under normal conditions the trees are expected to yield their maximum, before natural wintering takes place.

The remedial measures previously recommended have been tested on a plantation scale in Burma and have been found to be successful. The removal of seeds and the free admission of light and air by thinning and pruning have proved effective in reducing both leaf-fall and black thread on the tapping surface; but on account of the high cost of systematically removing the seeds it is doubtful if this measure is commercially practicable. In the Federated Malay States a regular application of Izal on the tapping cut has proved effective in preventing and checking black thread, but on a plantation in Burma where this disinfectant and others, such as, Solignum and Brunolinum, were given an extensive trial they have not been found to do much good; the reason is that in Burma there is more likelihood of the disinfectant being washed off in the more frequent heavy showers of rain than in the Federated Malay States where the rainfall is not as high as in Burma and is not confined to four months of the year.

The extent of the damage done by black thread on different plantations in Burma is not the same. The varying amounts of rainfall in the different rubber growing districts do not seem to have any direct bearing on the extent of the disease on the tapping cut, and on the amount of

damage done; but they seem to be proportional to the depth of the tapping cut. On a certain plantation where the rainfall is only 100 inches but where the tapping is very fine and deep, black thread is present in an epidemic form; not only is the percentage of diseased trees very high but the actual damage done to the bark is very great. But on other plantations where the rainfall is 200 inches or more but where the tapping is rather light, black thread is considerably less and seldom causes open wounds. These observations have also been confirmed by inoculation experiments.

(5) Chillies. *Die-back of chilli.* Experiments in the treatment of die-back, a very serious disease of chillies in Bihar, caused by *Vermicularia Capsici* Syd., have been continued by Mr. Dastur in the year under review. It has been found that one per cent. Burgundy mixture sprayed soon after the flowers set and again a fortnight later, considerably checks the disease, both on the plants and the fruits. The percentage of the disease in fruits picked from the sprayed plot of last year up to the first week of December (after which time the disease is practically negligible in the fields) was 7·6, while that on fruits from the unsprayed control plots was over 33. Not only did the freshly picked fruits from the sprayed plot compare favourably, in regard to the percentage of disease, with those from the unsprayed plots, but they also stood drying better, the market value of the sprayed fruits being thereby increased.

Another measure that proved successful in completely checking the disease was sowing the crop a month later than usual on a field manured at the rate of 2 cwt. of superphosphate and 1 cwt. of soda nitrate. The manure was applied to increase the yield of the late sown crop which would otherwise be very poor.

These and other measures will be again tried during the coming chilli season at the end of which it is hoped to publish a detailed account of the study of the die-back disease.

Anthracnose of chilli. During the year under review Mr. Dastur has continued the study of *Colletotrichum*

nigrum and *Glœosporium piperatum* on chillies, and has found that these two fungi are identical and that they are the conidial forms of *Glomerella cingulata* (Stoneman) Spauld. and v. Schrenk which is considered to be synonymous with *Glomerella piperata* (Stoneman) Spauld. and v. Schrenk.

A second disease of chillies, causing blossom and twig rot, was discovered during the progress of the investigation on anthracnose. It did as much damage as the chilli die-back. This disease is due to a fungus which has been identified as *Choanephora cucurbitarum* (B. and Rav.) Thaxt. It has not been previously known to occur in India but in America it is a serious pest of cucurbits.

(6) Fruit diseases. The spraying of peach orchards on the Government farm at Taru, North-West Frontier Province, against peach leaf curl was continued during the year under review. The difference between the sprayed orchards and unsprayed orchards became very marked as the season advanced and proved conclusively the advantage of spraying against this disease.

Specimens of crown gall on quince and pomegranate were collected in Peshawar orchards, this being the first time this destructive disease has been recognized in India.

A number of enquiries from apple orchards in Kumaun resulted in the following diseases of apple being identified :—

Root rot of apple due to the attack of Rosellinia. This fungus is well known as the cause of extensive damage in orchards in Europe and elsewhere. It appears to be most severe in strongly acid soils and an analysis of the soil from the orchard in question showed a marked deficiency of lime.

Apple cracking and branch blister. The cracking of apple fruits, which is common in these orchards, is due to the fungus *Coniothecium chomatosporium* Corda. This fungus has recently been the subject of investigation in South Africa and Europe—the parasite has been obtained in culture and will be kept under observation. A system of

spraying against this disease is being tested during the current season.

Fire blight. This destructive bacterial disease seems to be present in Kumaun orchards and will be kept under observation.

During the year under review the " foot rot " disease of papaya in Pusa was again investigated and found to be due to a species of *Pythium*. Infections with pure cultures of *Pythium* were successful in producing the disease and moreover the species of *Pythium* concerned appears to be identical with that which causes " damping off " of tobacco seedlings and soft rot of ginger. Excision of the diseased tissue and treatment of the wound with a wash of 50 per cent. carbolic acid in water appears to be effective remedy.

A ripe rot of peaches caused by a species of *Aspergillus* was for the first time found in Pusa during the past season. The same species has been known to attack mangoes as well.

(7) " Tikka " disease of groundnut. The groundnut crop is attacked by two distinct fungi, one the cause of true *tikka*, *Cercospora personata* (B. and C.) Ellis; the other, an undescribed species of *Cercospora*, which occurs commonly in the crop in various parts of India. The disease due to the unnamed *Cercospora* is apparently only known in India and, in the last ten years, has been collected in various parts of this country. The outbreak at Ranchi in the past year was the first case in which it was observed as a serious disease. In the Ranchi plots the distribution was quite erratic and did not seem to bear any relation to either the variety grown or the manurial treatment. It was exceedingly difficult, without microscopic examination, to distinguish the two attacks : the symptoms were similar, and the damage much about the same in both cases. It appeared to be a matter of chance which fungus was most prevalent in any particular plot. It is probable that the increased amount of this disease in the groundnut crop at Ranchi is due either to some deterioration in the plant or some unsuitability in the locality. It would possibly be worth

while testing the first of these possibilities by growing newly-imported varieties received direct from abroad or from some other part of India. It was found in Bombay that directly imported Madras seed did nearly as well as the foreign importations, but it was not known how long the Madras varieties had been in the country. The view that the disease in the crop is due to phosphatic depletion, suggested tentatively last year, must be abandoned.

(8) **Other diseases.** A damping off of tobacco seedlings due to *Pythium gracile* came under observation and control measures were tested. The treatment of seed beds with copper sulphate and sulphuric acid in varying proportions did not check the disease.

An outbreak of a fungal disease upon the Rangoon bean (*Phaseolus lunatus*) in Burma was attributed to the fungus *Phytophthora* in articles in the public press. Investigation of specimens showed that this diagnosis was quite erroneous and that the preliminary alarmist reports were without adequate foundation. This fungus is a sclerotial fungus and is under observation in culture at Pusa.

A serious outbreak of disease on opium poppy was reported by the Agricultural Adviser, Central India States, and proved to be due to *Erysiphe Polygoni*, a mildew not previously known as a parasite of poppy. The disease will be kept under observation during the coming season.

Work on sclerotial diseases of sugarcane and paddy was continued and the results are being prepared for publication. It has been established by inoculation that the sclerotial fungus which produces the disease known as "Djamoer Oepas" on sugarcane will infect upon paddy.

Some observations were made correlating the incidence of wilt disease in *rahar* (*Cajanus indicus*) with the composition of the soil. The results were obtained from the permanent manurial plots on the Pusa farm and the work will be continued every year. Field work on *tokra* of tobacco was continued and the results confirmed the conclusions published in the last annual report; the investiga-

tion will be carried on during the coming season with different varieties of tobacco seed obtained from other parts of India.

IV. Miscellaneous.

The year under review was marked by the passing of an order, under the Destructive Insects and Pests Act, regulating and restricting the importation of plants and seeds into British India. By the provisions of this order no plant may be imported into British India through the letter or sample post, and the importation of plants other than fruit and vegetables intended for consumption, potatoes and sugarcane is restricted to certain prescribed ports, where fumigation with hydrocyanic gas can be carried out. Since fumigation, although satisfactory in the case of insect pests, is not an efficient method of killing fungal parasites in seed and plants, the importation of fungal disease is provided against by a series of clauses regulating the introduction of potatoes, sugarcane, rubber plants, coffee plants, coffee, flax, berseem and cotton seeds. This list includes the plants and seeds on which the introduction of dangerous fungal diseases into India is most probable, and the provisions of the notification ensure that these plants shall only be introduced if accompanied by a certificate from a competent authority in the country of export stating that they are free from certain fungal parasites. In the case of coffee plants and seeds importation may only be done by the Madras Department of Agriculture.

Dr. Butler's book entitled *Fungi and Disease in Plants* was published during the year under review and supplies a long felt want in the literature of scientific agriculture in India.

Additions to the herbarium numbered 122 foreign specimens and 97 specimens collected in India.

V. Programme of work for 1918-19.

(1) *Research work.* New diseases of Indian crops that come to the notice of the Section will be investigated as

opportunity permits, but the following diseases will receive special attention and will constitute main lines of investigation :—

(*a*) Ufra of paddy.
(*b*) *Orobanche* of tobacco and mustard.
(*c*) Die-back and anthracnose of chilli.
(*d*) Sclerotial disease of sugarcane and paddy.
(*e*) Root rot of sál tree.
(*f*) Wilt disease of cotton, sesamum and pigeon-pea.
(*g*) Black ring disease of jute.
(*h*) Black thread disease of rubber.

Minor investigations will include the study of some fruit anthracnoses, soft rot of ginger, root rot of cotton and bud rot of areca palms.

It is hoped to publish a handbook of diseases of crops.

(2) *Systematic work.* This will be in abeyance for the present owing to difficulties in obtaining assistance from abroad on account of the war.

(3) *Training.* This will be continued on the lines indicated in the prospectus. Short courses may also be given as necessary.

(4) *Routine work.* Advice and assistance will be given as usual to Provincial Departments of Agriculture, the Forest Department, Planters' Associations and the general public.

VI. Publications.

(1) Butler, E. J. . Report on Mycology, 1916-17, for the Board of Scientific Advice.

(2) Butler, E. J. . Immunity and Disease in Plants. *Agri. Jour. of India,* Special Indian Science Congress Number, 1918.

(3) Butler, E. J. . Fungi and Disease in Plants, June, 1918.

REPORT OF THE IMPERIAL ENTOMOLOGIST.

(T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S.)

I. Administration.

The Imperial Entomologist held charge of the Section throughout the year ended 30th June, 1918. The post of Supernumerary Entomologist remained vacant throughout the year owing to the difficulty of obtaining any suitable candidate under present conditions. Mr. Y. Ramachandra Rao, M.A., Entomological Assistant in Madras, was on deputation throughout the year to work under the Imperial Entomologist on an investigation of the insects which occur on *Lantana* in India and Burma.

II. Training.

One student, V. G. Deshpande, B. Ag., deputed by the Bombay Department of Agriculture, was received on 1st June for a special short course in Entomology.

III. Insect Pests.

The numerous observations made on Insect Pests during the year under review cannot be given in detail here, and a Report of this nature is necessarily restricted to inclusion of the more important or interesting facts elicited anent the more important pests dealt with during the year. A summary of our knowledge of Indian Crop-pests up to practically the end of the preceding year has been published in the "Report of the Proceedings of the Second Entomological Meeting," to which the following observations may be regarded as supplementary.

Cotton. Work on Cotton Bollworms was continued throughout the year. From the data available it is found that at Pusa, at the beginning of the cotton season, especially from July to the middle of October, *Earias fabia* and *E. insulana* are the bollworms mostly present, but later on, from the middle of October to the end of January, the Pink Bollworm, *Platyedra* (*Gelechia*) *gossypiella*, is mostly

present and damages the crop considerably. This latter period covers the cotton-picking season and it is then that *P. gossypiella* is at its worst. The bollworm parasite, *Microbracon*—probably more than one species are concerned—which normally parasitizes *Earias*, is also able to parasitize the larvæ of *P. gossypiella* whilst these are in the shoots and pods of the plant; but it seems to be unable to attack the larvæ once these have got into the cotton-seeds. Large numbers of the larvæ in cotton-seeds were collected and bred out in the quest for parasites but not a single parasite was reared from these. It is undoubtedly owing to the absence of control by natural parasites that *P. gossypiella* is so destructive in some parts of India, notably the United Provinces, and it seems likely that its control will be best effected by the discovery and introduction of an efficient natural parasite. This is not a problem which affects India only, the control of this pest being equally important to Egypt, the United States and practically all the cotton-growing districts throughout the World; but *P. gossypiella* is apparently endemic in India and it therefore seems possible that the required parasite, if such exists, is most likely to be found in India.

As in previous years, the best trap-crop for bollworm larvæ was *Hibiscus abelmoschus*. At the beginning of the cotton season, when *Earias* were increasing, the pods and shoots of *H. abelmoschus* were found to contain a relatively larger number of parasitized bollworms than did either cotton or any other trap-crop. The advantage, so far as incidence of insect pests is concerned, of sowing cotton intermixed with another crop was apparent as in the previous year, but *Cajanus indicus* (*tur*, *arhar*) is not a good crop to be inter-sown with cotton.

Pempheres affinis was very bad this year in the cotton plots and many varieties suffered so badly that they had to be removed. On some varieties *Pseudococcus* sp. was very destructive, and others were attacked by *Machærota planitiæ* so badly that the infested plants had to be removed. A mite, *Eriophyes* sp., was also bad on a few varieties.

Rice. Stem-borers in rice were under observation throughout the year as far as it was possible with the staff available. The insects concerned were (1) *Schœnobius bipunctifer*, (2) *Chilo simplex*, (3) a second species of *Chilo*, as yet unidentified and apparently undescribed, hitherto confused with *C. simplex*; this is for the present called Rice Chilo, (4) *Sesamia inferens.*

Whilst rice was growing it was observed that the prevalence of these borers varied from field to field and also to some extent according to the age of the plants. Considerable further observation is required in order to arrive at definite facts and conclusions regarding their relative prevalence.

Sesamia inferens remained active throughout the year, whilst the other three species mentioned above hibernated in the stubble. In order to observe the hibernating habits of these insects four large rice fields outside the Pusa Estate, amounting in the aggregate to about 180 acres, were kept under observation throughout the cold weather from December to March, samples of stubble being collected at intervals from all over these fields and examined. As a result of the examination of 18,514 stubble-stems it was found that :—

(1) Reckoning as affected only those stems which showed distinct signs of borer attack, the percentage of damage varied from 14 to 55 in the various countings and on the average was about 29. As attack by a borer causes the entire ear to fail to develop, this percentage may be taken as representing the proportion of chaff in the harvested grain.

(2) At the lowest computation there were about 30,000 larvæ hibernating in each acre of the rice fields in December. This number fell to about 15,000 per acre towards the end of March. This reduction was apparently due to the fact that, as the temperature rose at the end of the cold weather, these hibernating larvæ became active and left the stubble, and either fell victims to natural enemies or took shelter in cracks in the soil. In the samples of stubble, however, there was no sign of the presence of any enemy worthy of

the name, so that the larvæ seem fairly safe from such whilst they remain in the stubble. Towards the end of the season many *Schœnobius* larvæ were found dead and dry inside the stubble, but dead larvæ of the two species of *Chilo* were rarely met with. This fact is in accordance with the habits of the larvæ, those of *Schœnobius* being extremely sluggish and too slow to move to safer quarters when climatic conditions in the stubble become unfavourable. The following table shows in detail the main facts about these hibernating larvæ :—

Dates between which stubble was collected and examined.	No. of stems examined	No of stems which had been damaged by borers	Total number of larvæ actually found	Percentage of larvæ in column 4				Percentage of dead *Schœnobius*, larvæ in total number shown in previous column
				Sesamia inferens	*Chilo simplex*	Rice Chilo	*Schœnobius bipunctifer*	
5th-20th December, 1917 .	7,255	2,109	363	0·8	12·7	63·6	22·9	9·6
25th January-28th February, 1918.	6,484	2,001	284	..	4·9	14·8	80·3	21·0
18th-21st March, 1918 .	4,775	1,260	110	..	14·6	31·8	53·6	40·7
TOTAL . .	18,514	5,370	757	..	..	..	..	..

During this last examination, in the third week of March, it was found that the percentage of dead in the total number of *Schœnobius* larvæ found was about 66 in the case of stubble which had been ploughed some time previously and allowed to lie exposed to the sun, whilst it was only 28 in the case of larvæ found in the unploughed stubble. The simple process of ploughing the stubble at this time of year had therefore brought about the death of a very large percentage of *Schœnobius* larvæ. Before advocating this as a routine practice, however, further observations are desirable. Further work on these rice-borers was discontinued at the end of March when the adults began to emerge in the Insectary from the larvæ collected from the stubble.

In recent years crabs have come into prominence as pests of rice-plants in the Indian Empire, and, although not strictly subjects for entomological investigation, some work has been done on them in their capacity as crop-pests,

because it appears to be nobody else's business to do anything in this line. They cut the rice-plants, especially the young plants, and are reported to damage rice in this way in Burma, Madras, some parts of the Bombay Presidency and also in some parts of Bihar. They are known to occur in rice fields in Western Bengal but not as doing any damage there. About six miles from Pusa there is a large rice-growing tract known as Barail where crabs were reported to be doing great damage, and this locality was visited in October, at the end of the Rains, and again in April, in the dry weather. The crabs collected from the rice-fields here were identified by Mr. S. W. Kemp, as belonging to three distinct species, *viz.*, (1) *Paratelphusa* (*P.*) *spinigera*, Wood-Mason, (2) *Potamon* (*Acanthopotamon*) *martensi*, Wood-Mason, (3) *Potamon* (*A*) sp. nov. allied to *wood-masoni*, Alcock. Apparently all these three species are not concerned in the damage to rice, but it requires further observations to determine which species are incriminated. From observations made hitherto it appears that these crabs take three or four years to become fullgrown and capable of reproduction. In the hot weather they go deep down into the soil, coming out and resuming activity in the Rains. From a dry field at Munni, in the Muzaffarpur District, in April five crabs, young as well as adults, were collected at a depth of between 11 and 13 feet below the ground; of these five, three were *P. spinigera* and two were *P. martensi*.

Sugarcane. Considerable attention has again been paid during the year to the important subject of cane-borers and to the question of alternative wild foodplants of these. In the past, several different species of borers, all superficially much alike, were mixed up together under the name of Moth Borer (*Chilo simplex*), which was supposed to attack sugarcane, *juar* (*A. Sorghum*), maize and rice. In last year's Report it was mentioned that this "Moth Borer" had been differentiated into four distinct species. Further research during the year has extended this number until we can now discriminate no less than ten forms distinguishable from one another by morphological differences in their

larval and pupal stages, these differences being most easily appreciable in the pupæ as a rule. As regards the adults, except in a few cases, the types of coloration and pattern of markings are very uniform in all the species, and it is extremely difficult to distinguish these or to make the minute distinctions between them easily apparent by description or figures; study of the male genitalia has, however, indicated that the differences found in the immature stages correspond with differences in these structures, and further study of more ample material will doubtless enable us to differentiate between the adults, a thing which we are unable to do at present with any real satisfaction.

The nomenclature of these various forms is at present in such a state of confusion that it seems inadvisable to apply any names at all pending a thorough systematic revision of the whole of this group. Many of the species now discriminated are probably undescribed, and the application of the names in the cases of those species of which descriptions have been published is extremely doubtful in most cases. In last year's Report, for example, I referred to a species under the name of *Diatræa suppressalis* (*auricilia*), quoting *auricilia*, Ddgn., as synonymous with *suppressalis*, Wlk., on the authority of Sir George Hampson (*Bombay N. H. S. Journal*, XXI, 1250); further examination, however, shows that our cane-borer, which is apparently identical with *auricilia* (specimens of which, named by Dudgeon himself, are in the Pusa and Indian Museum collections), is quite distinct from examples agreeing exactly with the " Fauna " description of *suppressalis*, which latter species we have not bred as yet either from cane or any allied plant and whose early stages are as yet unknown to us although it is sufficiently common at Pusa. It may also be queried whether *Diatræa striatalis*, described by Snellen from Java, is truly synonymous with *venosata*, Wlk., from Sarawak. It seems better, therefore, to refer to these different species at present simply under the numbers of the Cage-slips under which they have been reared at Pusa, leaving to the future the allocation of exact specific names.

The names used here for these borers (*Chilo* and *Diatræa* spp.) in Gramineous plants must be regarded for the present only as those under which we have known these species hitherto, without any guarantee of accuracy of application, and they are only given here to allow of comparison between the current Report and that for last year.

Bearing the above remarks in mind, we may now turn to the species distinguished up to date. Those included in last year's Report were :—

(1) *Chilo simplex* (C. S. 1561 and 1580). (Plate III.)
(2) *Diatræa auricilia* (C. S. 1560 and 1574). (Plate IV.)
(3) *Diatræa venosata* (C. S. 1607 and 1635). (Plate V.)
(4) *Diatræa* sp. (C. S. 1610). (Plate VI.)

In addition to these we have now discriminated :—

(5) ? *Diatræa* sp. in sugarcane at Dacca (C. S. 1674). (Plate VII.)
(6) Rice Chilo in rice at Pusa (C. S. 1677). (Plate VIII.)
(7) ? *Chilo* sp. in rice (C. S. 1768).
(8) ? *Chilo* sp. in *Saccharum arundinaceum* (C. S. 1769).
(9) ? *Chilo* sp. in *Saccharum fuscum* (C. S. 1795).
(10) ? *Anerastia ablutella* in sugarcane (C. S. 1801). (Plate IX.)

Of these, the first six occur in large numbers, whilst the last four have only been found in very small numbers. Of these ten, three (C. S. 1768, 1769 and 1795) have as yet been insufficiently studied, but the other seven species may be separated in their larval and pupal stages by means of the following dichotomic keys, and figures are added to enable the distinctions to be grasped more readily.

Key to larval forms of Borers.

1.	Spiracles round	(C. S. 1801)
	Spiracles oval	2
2.	With mid-dorsal stripe; spiracles open	3

EXPLANATION OF PLATE III.

Fig. 1. *Chilo simplex* (C. S. 1580).

a, lateral, and, *b*, dorsal view of larva, × 5.
c, details of spiracle on fifth segment, more highly magnified.
d, details of first proleg, seen from below, more highly magnified.
(*Note.*—Anterior hair on right side of anal plate was absent in this specimen.)

Fig. 2. *Chilo simplex* (C. S. 1561).

a, Pupa, × 5.
b, Posterior segments of pupa, lateral view, more highly magnified.
c, Anal segment of pupa, ventral surface, more highly magnified.

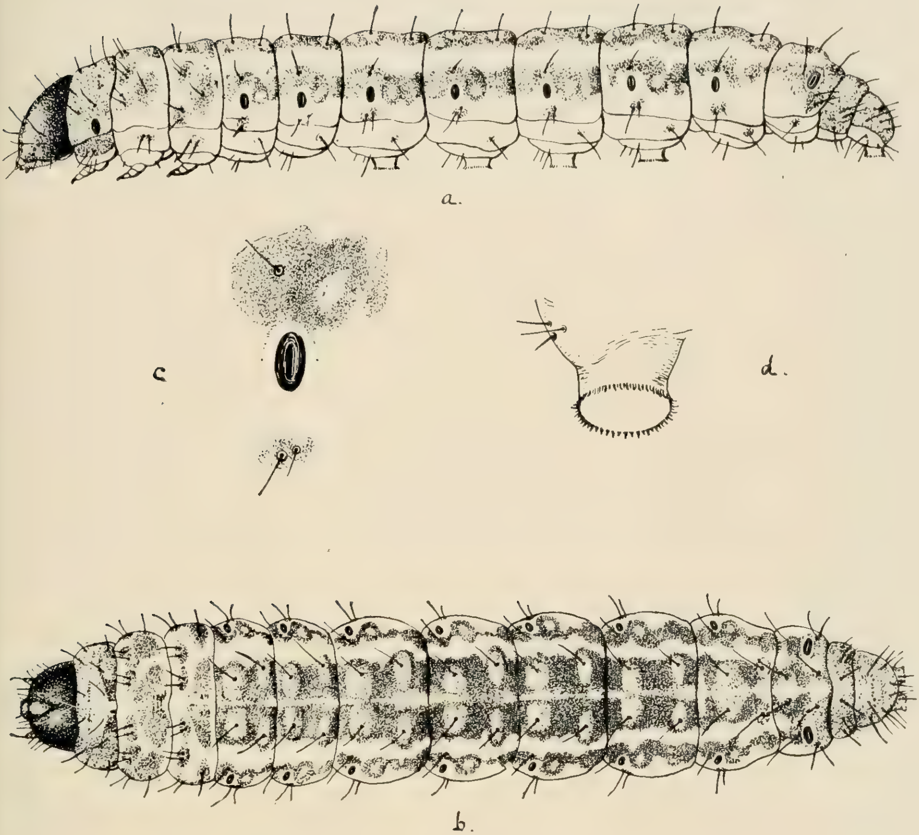


Fig. 1. *Chilo simplex* (C. S. 1580).

Fig. 2. *Chilo simplex* (C. S. 1561).

EXPLANATION OF PLATE IV.

Fig. 1. *Diatræa auricilia* (C. S. 1574).

a, lateral, and, *b*, dorsal view of larva, × 5.
c, details of spiracle on fifth segment, more highly magnified.
d, details of proleg, seen from below, more highly magnified.

Fig. 2. *Diatræa auricilia* (C. S. 1560).

a, Pupa, × 5.
b, Posterior segments of pupa, seen laterally, more highly magnified.
c, Anal segment of pupa, ventral surface, more highly magnified.

PLATE IV.

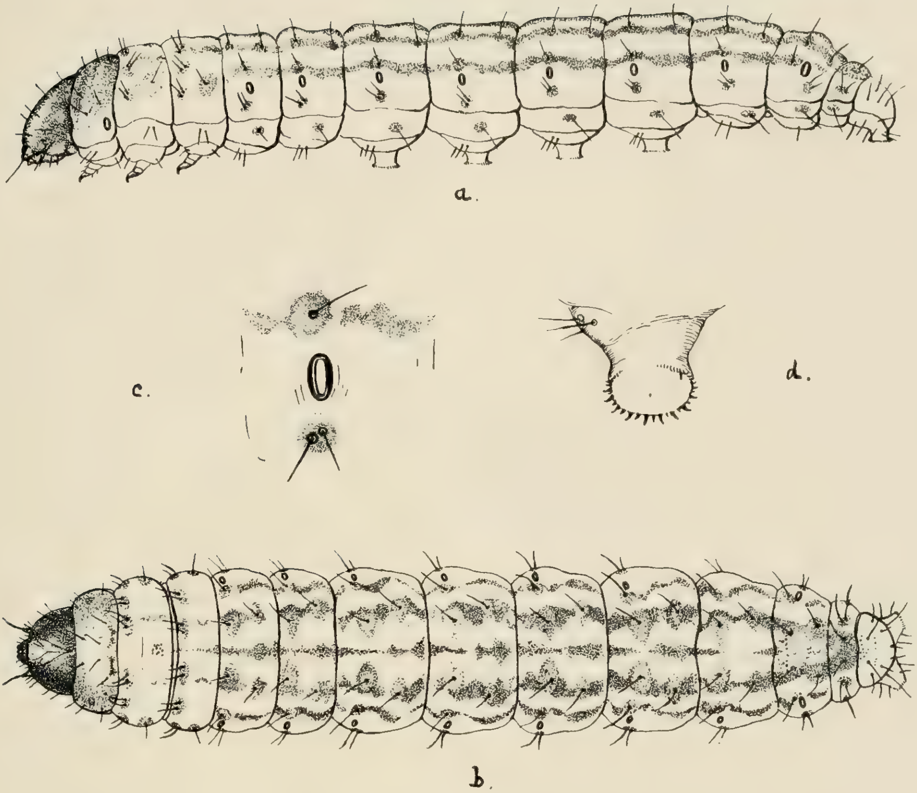


Fig. 1. *Diatræa auricilia* (C. S. 1574).

Fig. 2. *Diatræa auricilia* (C. S. 1560).

EXPLANATION OF PLATE V.

Fig. 1. *Diatræa venosata* (C. S. 1635).

a, lateral, and, *b*, dorsal view of larva, $\times 4$.
c, details of spiracle of fifth segment, more highly magnified.
d, details of first proleg, seen from below, more highly magnified.

Fig. 2. *Diatræa venosata* (C. S. 1607).

a, Pupa, $\times 5$.
b, Posterior segments of pupa, lateral view, more highly magnified.
c, Anal segment of pupa, ventral surface, more highly magnified.

PLATE V.

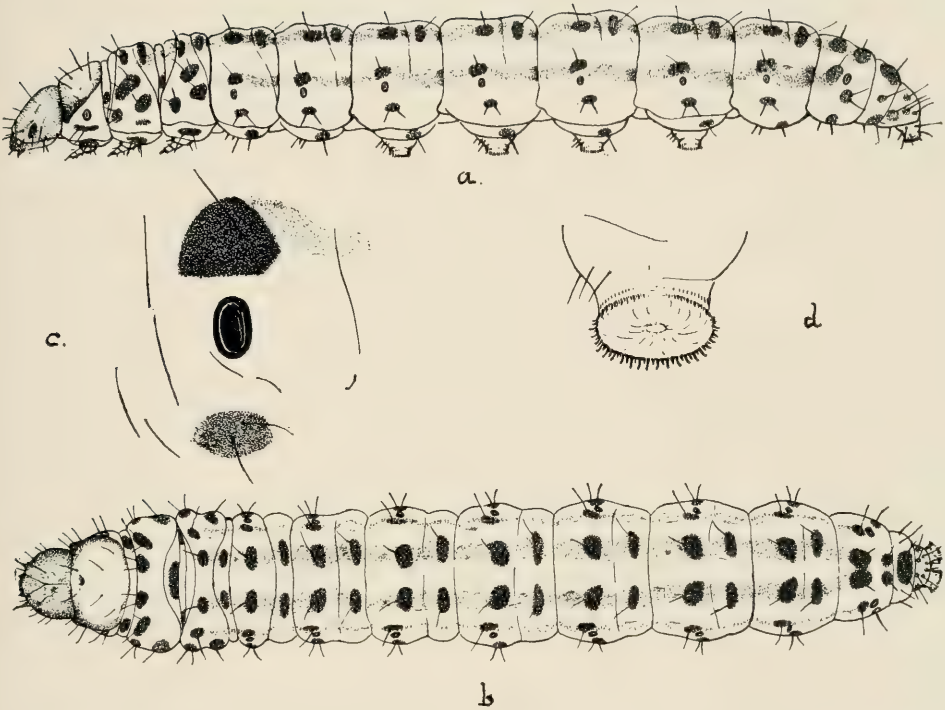


Fig. 1. *Diatræa venosata* (C. S. 1635).

Fig. 2. *Diatræa venosata* (C. S. 1607).

EXPLANATION OF PLATE VI.

Fig. 1. *Diatræa* sp. (C. S. 1610).

a, lateral, *b*, dorsal, and, *c*, ventral view of larva, ×4.
d, details of spiracle on fifth segment, more highly magnified.
e, details of proleg, seen from below, more highly magnified.

Fig. 2. *Diatræa* sp. (C. S. 1610).

a, Pupa, ×4.
b, Posterior segments of pupa, seen laterally, more highly magnified.
c, Anal segment of pupa, ventral surface, more highly magnified.

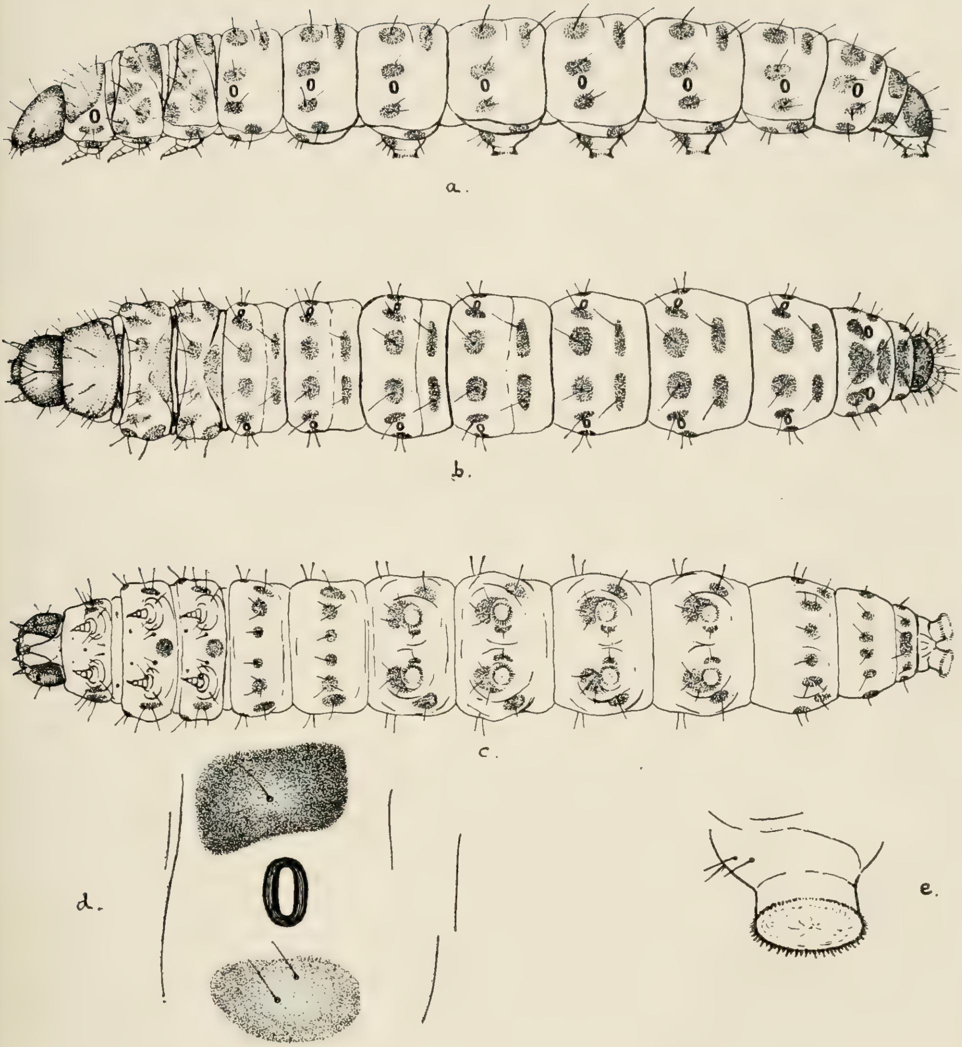


Fig. 1. *Diatræa* sp. (C. S. 1610).

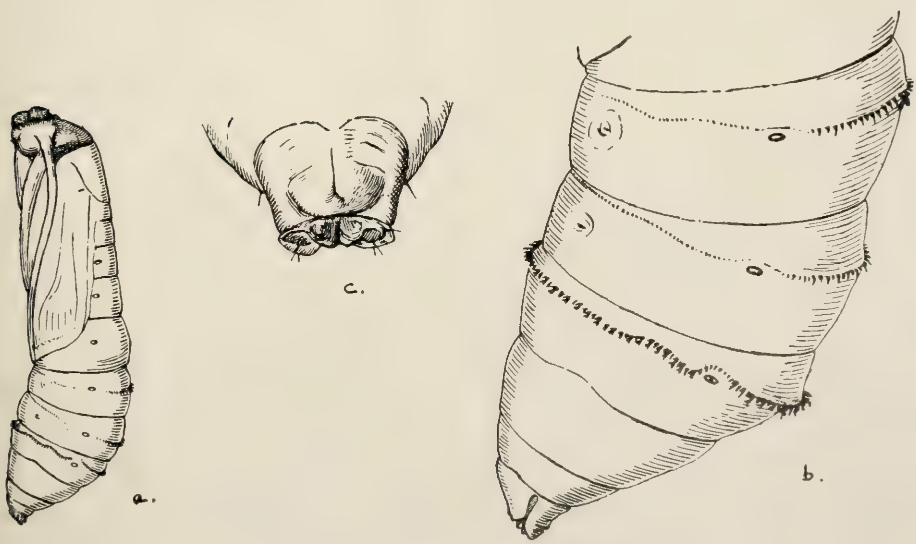


Fig. 2. *Diatræa* sp. (C. S. 1610).

EXPLANATION OF PLATE VII.

Fig. 1. ? *Diatræa* sp. in sugarcane at Dacca (C. S. 1674).

a, lateral, and, *b*, dorsal view of larva, × 4.
c, details of spiracle on fifth segment, more highly magnified.
d, details of first proleg, seen from below, more highly magnified.

Fig. 2. ? *Diatræa* sp. in sugarcane at Dacca (C. S. 1674).

a, Pupa, × 5.
b, Posterior segments of pupa, seen laterally, more highly magnified.
c, Anal segment of pupa, ventral surface, more highly magnified.

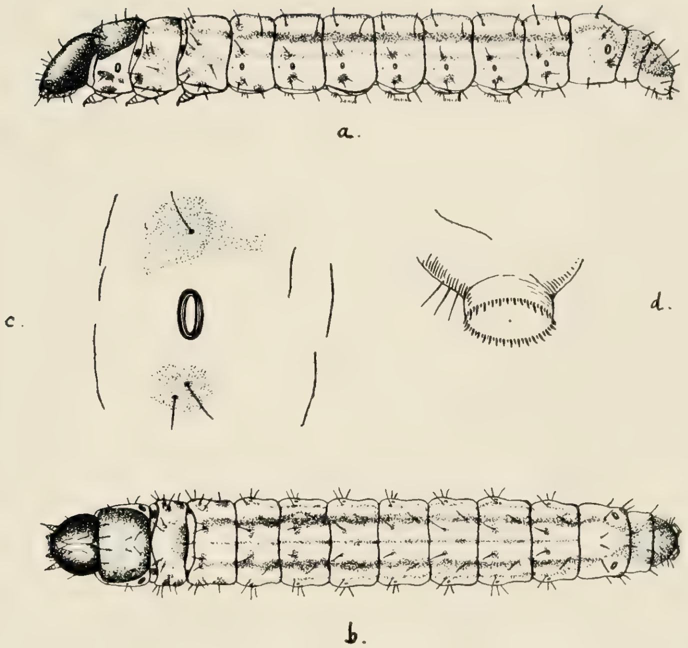


Fig. 1. ? *Diatræa* sp. in sugarcane at Dacca (C. S. 1674).

Fig. 2. ? *Diatræa* sp. in sugarcane at Dacca (C. S. 1674).

EXPLANATION OF PLATE VIII.

Fig. 1. Rice Chilo in rice at Pusa (C. S. 1677).

a, lateral, and, *b*, dorsal view of larva, × 5.
c, details of spiracle on fifth segment, more highly magnified.
d, details of first proleg, seen from below, more highly magnified.

Fig. 2. Rice Chilo in rice at Pusa (C. S. 1677).

a, Pupa, × 5.
b, Posterior segments of pupa, seen laterally, more highly magnified.
c, Anal segment of pupa, ventral surface, more highly magnified.

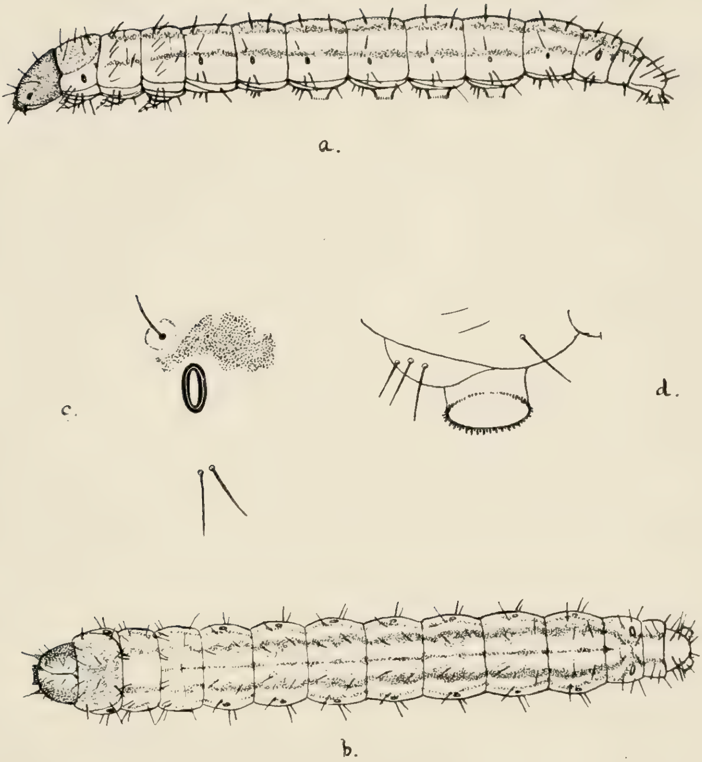


Fig. 1. Rice Chilo in rice at Pusa (C. S. 1677).

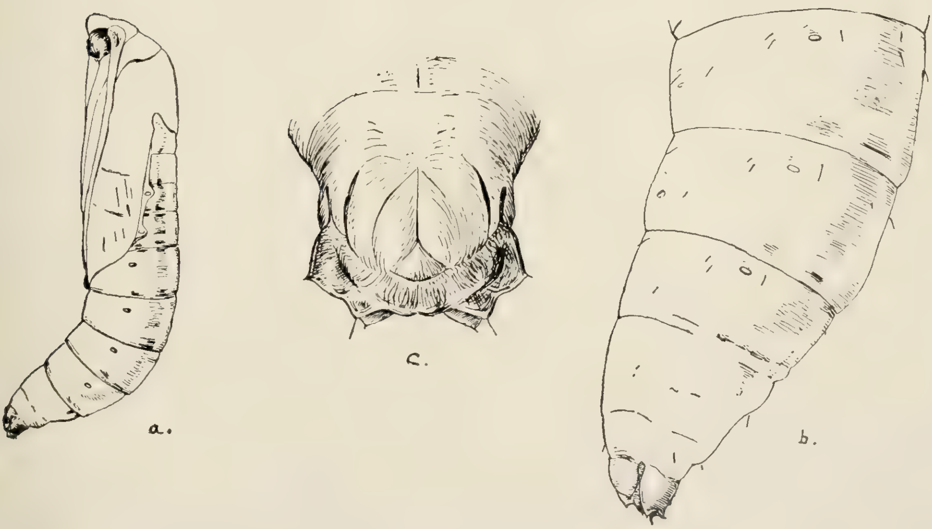
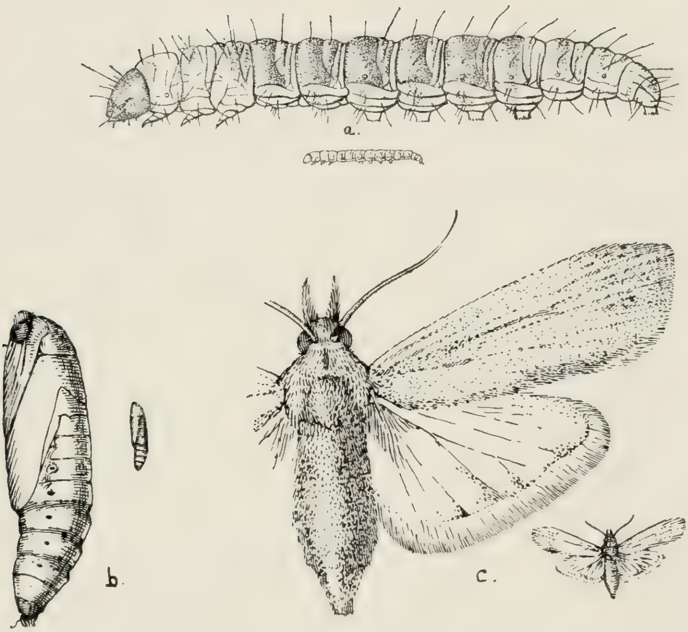


Fig. 2. Rice Chilo in rice at Pusa (C. S. 1677).



? *Anerastia ablutella* in sugarcane (C. S. 1801).

a, Larva, × 5.
b, Pupa, × 5.
c, Imago, × 5.
The smaller figures show the natural sizes.

Without mid-dorsal stripe; spiracles open or closed.	5
3. Hooklets on prolegs forming a complete circle.	4
Hooklets on prolegs forming a half-circle only.	(C. S. 1560, 1574)
4. Hooklets practically equal in size .	(C. S. 1674)
Hooklets on internal edge of sole largest and gradually diminishing in size externally.	(C. S. 1677)
5. Spiracles open (*i.e.*, with a clear space inside).	(C. S. 1610)
Spiracles closed (*i.e.*, without a clear space inside).	6
6. Spiracles with a slit along their major axis. Hooklets on prolegs forming a complete circle and all of equal size.	(C. S. 1561, 1580)
Spiracles with an oval-shaped concavity whose major axis coincides with that of spiracle. Hooklets on prolegs in a more or less complete circle but becoming shorter externally. A spot in middle of sole of prolegs usually present. Usually with shiny large dark-brown warts (absent in hibernating larvæ).	(C. S. 1607, 1635)

Key to pupal forms of Borers.

1. Pupa without any chitinous protuberances on anal segment.	(C. S. 1801)
Pupa with chitinous protuberances on anal segment.	2
2. Pupa without ridges or hooks on 7th abdominal segment.	(C. S. 1677)
Pupa with such	3
3. With complete circle of ridges, hooks, or roughness on 7th abdominal segment.	4
With incomplete circle as above .	5
4. Circle composed of distinct and separate spinous hooks.	(C. S. 1610)

	Circle composed of joined ridges . .	(C. S. 1560, 1574)
5.	Incomplete circle of distinct hooks .	(C. S. 1674)
	Incomplete circle of roughness without hooks.	6
6.	Tenth abdominal (anal) segment with stout spines on ventral surface in addition to two pairs of spines on dorsal surface.	(C. S. 1561, 1580)
	Tenth abdominal (anal) segment without spines on ventral surface.	(C. S. 1607, 1635)

Chilo simplex (C. S. 1561, 1580), *Diatræa auricilia* (C. S. 1560, 1574), *D. venosata* (C. S. 1607, 1635) and the Rice Chilo (C. S. 1677) have been observed to hibernate in the larval stage.

Not much is known about C. S. 1610 and C. S. 1674, two species found in cane at Dacca; of the former a single specimen was also reared from a rice stem sent from the Karimganj Subdivision in Sylhet, and a single example of the latter has recently been found in rice at Pusa. Both these species were found to be injuriously prevalent in sugarcane at Dacca in July 1917, whilst the ordinary cane-borers found in other parts of India were not found at Dacca. Sugarcane in Sylhet seems to be remarkably free from borers, and the Entomological Assistant in Assam reports that borers give little trouble in cane in that Province. It is therefore the more curious that C. S. 1610, which is present in Sylhet and injurious to cane at Dacca, does not damage cane in Sylhet; and similarly that C. S. 1674, which was also injurious to cane at Dacca, has not yet been found at all in cane at Pusa, although it occurs in rice in this district. Extensive fieldwork, combined with a thorough study of the different species of borers, will doubtless throw more light on these and similar problems. Meanwhile it may be suggested that the damage done to cane or any other similar crop by any particular borer may be connected with the presence or absence in the district of particular alternative foodplants which are preferred.

A good deal of work has been done during the year on borers and other insects occurring in the several species of

wild *Saccharum* and other grasses occurring in the neighbourhood of Pusa. Besides *Diatræa venosata, D. auricilia, Sesamia inferens* and *S. uniformis*, which are also found in sugarcane, nine other borers not yet known to occur in cane have been found in these wild grasses. Of these one is a Curculionid grub, another a Lamiad grub, and the remainder are lepidopterous larvæ, these including *Scirpophaga* sp., and *Papua* sp., a Zeuzerid and a Noctuid. This last has since been found to occur in sugarcane at Munni, Muzaffarpur District, and all of these insects may be looked on as potential pests of cane. Almost all of the root-feeders mentioned under cane have also been found to occur amongst the roots of these wild grasses.

Besides borers, the insects, mostly coleopterous larvæ, found underground amongst the roots of sugarcane, were under observation during the year, the following being noticed :—

(1) *Anomala bengalensis.*
(2) *Anomala biharensis* (Plate X).
(3) *Adoretus caliginosus* (Plate XI).
(4) *Autoserica* sp. (Plate XII, fig. 1).
(5) *Myllocerus discolor.*
(6) *Myllocerus blandus.*
(7) *Monolepta signata* (Plate XII, fig. 2).
(8) *Formicomus* sp.
(9) *Pachnephorus* sp.
(10) *Alissonotum piceum.*
(11) *Alissonotum simile.*
(12) *Apogonia* sp.
(13) An unidentified Chrysomelid.

Besides the above, one Chrysomelid grub and two kinds of weevil grubs were found but could not be reared out.

Of these insects, the grubs of *Anomala bengalensis* were observed both at Pusa and Dacca to gnaw into the basal parts of new shoots from the side, thus causing a "dead-heart;" in this way they were causing a small amount of damage. In the case of the other insects, no appreciable

idea could be formed of the part they were playing, but they appear to be of very minor importance as pests.

Records of observations on the pests of sugarcane at Pusa were given in last year's Report. These observations were continued during this year although it has not been possible to keep such close observation on the different varieties of cane as was done last year. The period of injurious activity of the borers in cane extended from March to August, when the total damage due to insects and fungi amounted to about 35·5 per cent., due to the following causes :—

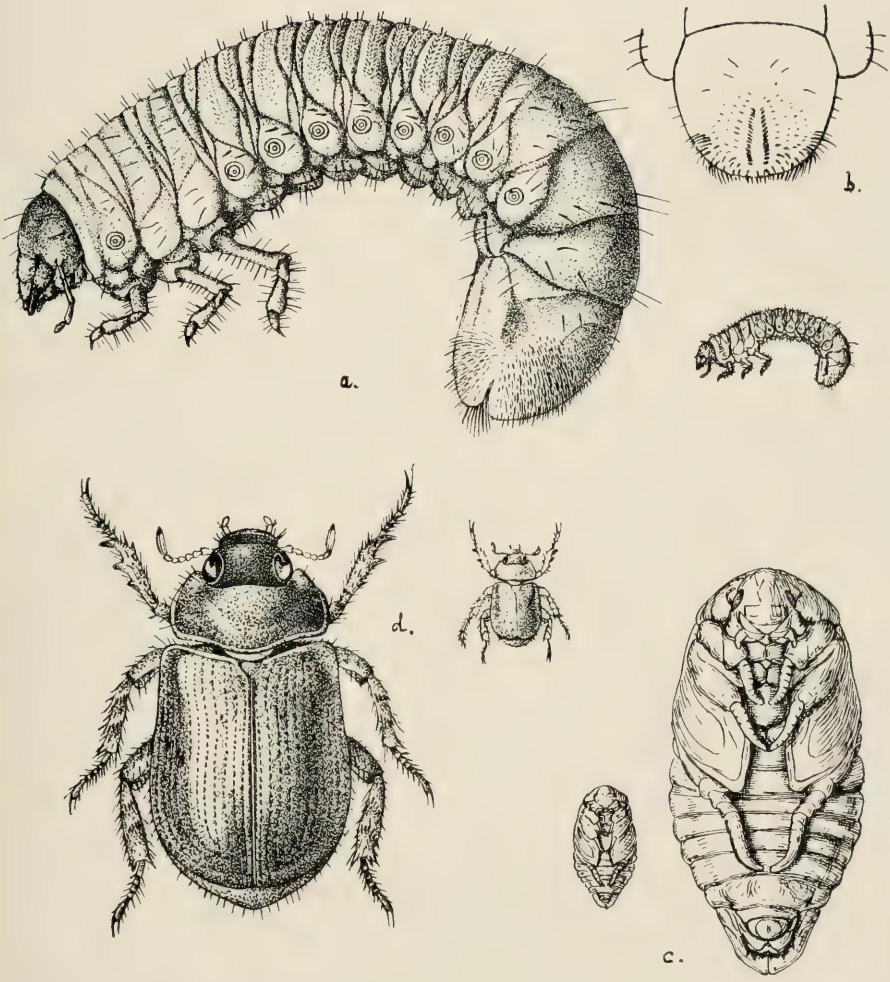
Fungal diseases	21·8 per cent.
Papua depressella	8·3 ,,
Diatræa auricilia with a few *D. venosata* .	2·7 ,,
Scirpophaga xanthogastrella . . .	1·9 ,,
Termites	0·8 ,,

At this time there was a distinct difference between the canes which would go to make up the harvest and those which were retarded in growth by pests and diseases. The monsoon rains had stimulated the growth of the former and they were growing vigorously, while the latter remained stunted and ultimately died, and, although new shoots and lateral branches were appearing, these would not add materially to the harvested result. The activity of the borers after August was mostly confined to these stunted canes and new shoots.

As mentioned in last year's Report, the plot of Purple Mauritius sugarcane had all "dead-hearts" and dry plants systematically removed together with the insects found in them. As this is the treatment usually recommended against borers in cane, the results obtained in this plot and in the other plots of thick canes which were left untreated and undisturbed seem interesting and appear to show the uselessness of the cutting-out treatment. The percentage of non-stunted, harvestable canes actually harvested to the number of setts planted may be taken as a standard of comparison,* as this shows the number of canes which survived

* The actual outturn of sugar would be the most satisfactory comparison between the various plots, but this cannot be adopted at Pusa because sugar is not made here.

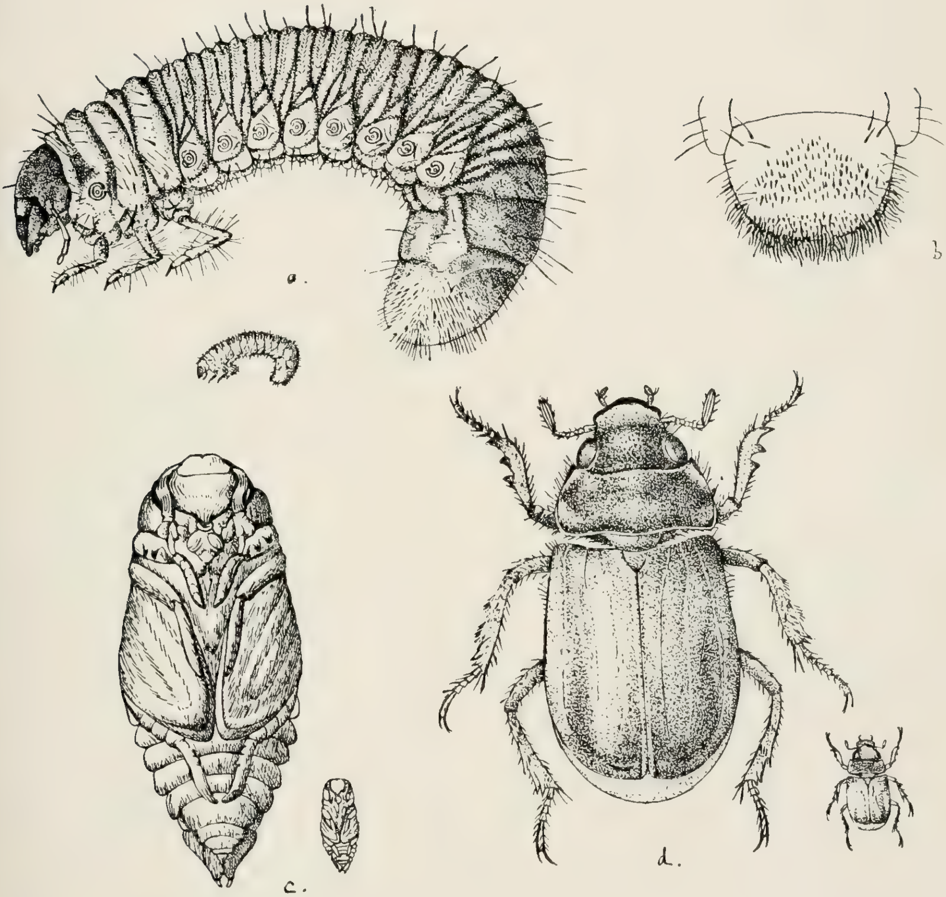
PLATE X.



Anomala biharensis (C. S. 1744).

a, Larva, natural size and magnified × 4.
b, details of posterior extremity of larva.
c, Pupa, natural size and enlarged.
d, Imago, ,, ,, ,, ,,

PLATE XI.



Adoretus caliginosus (C. S. 1793).

a, Larva, natural size and magnified × 5.
b, details of posterior portion of larva, magnified.
c, Pupa, natural size and magnified.
d, Imago.

EXPLANATION OF PLATE XII.

Fig. 1. *Autoserica* sp. (C. S. 1654).

a, Larva, natural size and magnified (× 8).
b, details of posterior portion of larva, magnified.
c, Pupa, natural size and magnified (× 8).
d, Imago, „ „ „ „ „

Fig. 2. *Monolepta signata* (C. S. 1632).

a, Larva, natural size and magnified (× 8).
b, Pupa, „ „ „ „ „
c, Imago, „ „ „ „ „

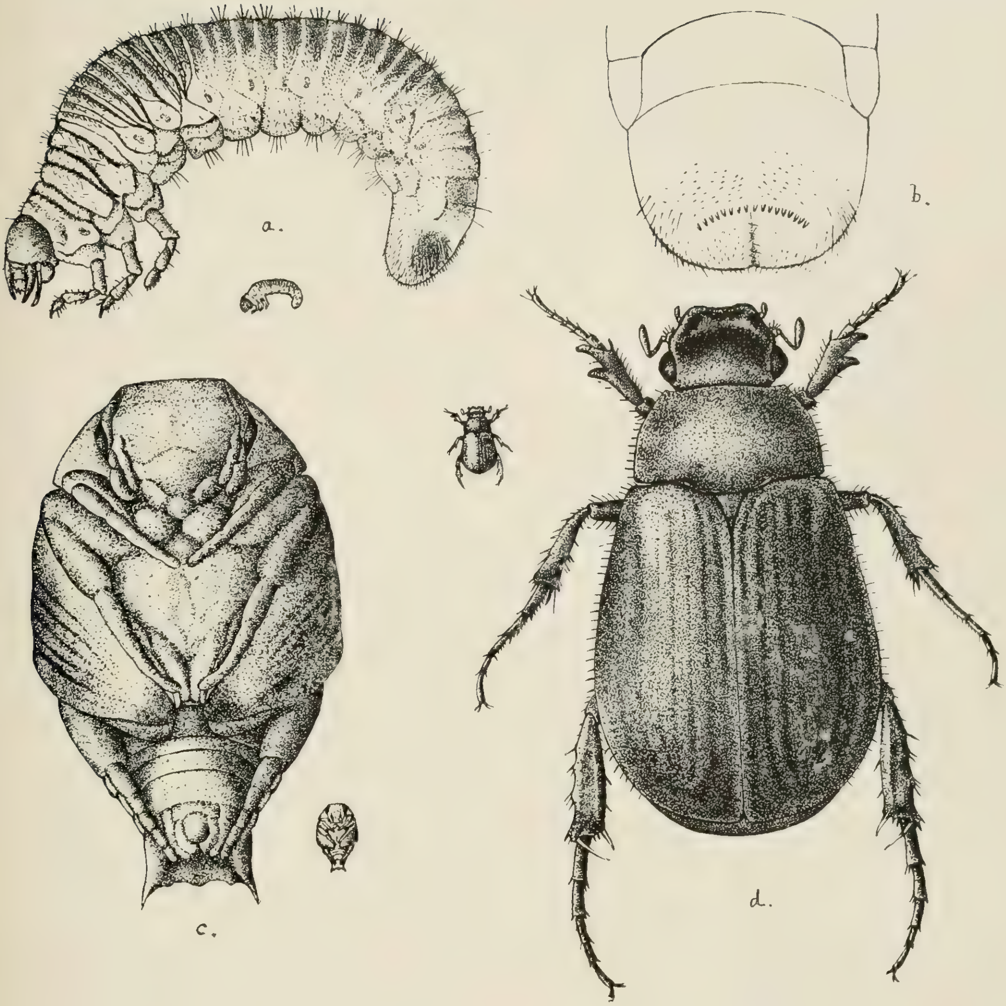


Fig. 1. *Autoserica* sp. (C. S. 1654).

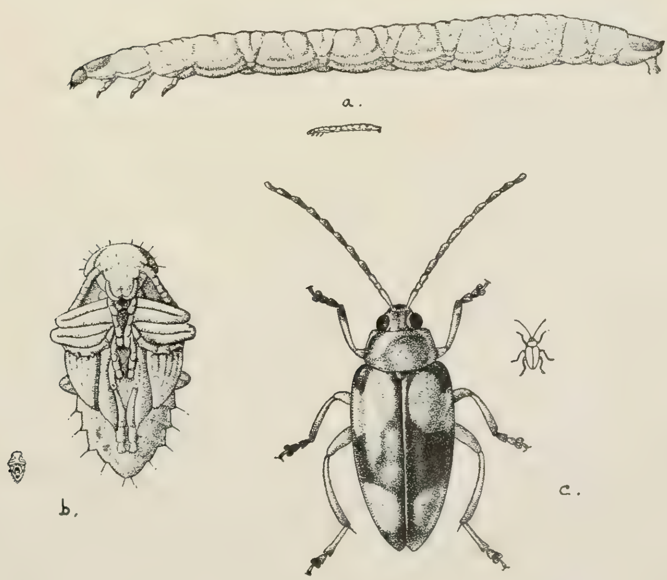


Fig. 2. *Monolepta signata* (C. S. 1632).

and outgrew the attack of pests and diseases. This percentage in the case of the different thick varieties enumerated in last year's Report was :—

Purple Mauritius (treated)	82 per cent.
Sathi No. 131 (untreated)	167 ,,
Sathi No. 15 (untreated)	161 ,,
Kaludai Budhan (untreated) . . .	101 ,,
D. 99 American (untreated) . . .	129 ,,

From the half-acre under Purple Mauritius, 14,277 affected shoots had been cut out, whilst the other plots were left undisturbed. The harvested canes in the case of these other plots therefore contained an unknown quantity of canes which, though classed as non-stunted and harvestable, had been presumably bored more or less, and the outturn of sugar from such bored canes would be poorer in quality and quantity than from unbored canes. The above percentages therefore fail to give an exact estimation of borer damage. It was unfortunate that no check plot of Purple Mauritius was available last year for observation and comparison of results, but in February, 1918, two half-acre plots of Sathi No. 131 were planted, one for treatment by cutting out and removing plants and shoots which were dry or showed " dead-heart " together with the insects found in them, and the other to be left untreated as a check. These two plots are practically similar as regards soil, are not contiguous (having a crop of indigo separating them), and are situated at a considerable distance from the main sugarcane crop of the Farm. The results so far obtained (up to July, 1918) go far to corroborate those obtained in the Purple Mauritius plot and to show that the cutting-out treatment retards the proper growth of the canes to a great extent.

The foregoing trials have been made with thick canes because these are more liable to borer attack, the thin varieties being damaged to a much smaller extent. With one exception the yield of canes in the seventeen thin varieties ranged from 122 to 746 per cent. of setts planted.

The two experimental plots of Sathi No. 131 referred to above are situated in a piece of land which was brought

under cultivation five or six years ago. It was previously a piece of waste land overgrown with *Saccharum spontaneum* and *Imperata arundinacea*, and it is even now bordered by similar waste lands. Sugarcane grown on this land has brought *Gryllotalpa africana* prominently into notice as a pest of young cane. This insect was the first to attack the young crop and in April and May in the treated plot as many as 15 per cent. of the plants were damaged by it.

In last year's Report mention was made of the suitability of Lead Arsenate solution as a dip for the protection of cane setts against termites. This year it was tried in the half-acre treated plot of Sathi No. 131, a strength of 1 lb. of Lead Arsenate in two gallons of cold water being used. The planting was done in the third week of February, and germination was good in both the treated and untreated plots. In April and May new shoots as well as the setts themselves were damaged by termites in both the plots, and those dipped in the Lead Arsenate solution had no advantage over those left untreated. The liability of cane to damage by termites seems to depend largely on the nature of the soil in which it is grown. Generally speaking, the crop suffers much less when grown in clayey soils than in sandy soils. In soils which are liable to be infested by termites, no single treatment of the setts can render them permanently immune from attack nor can it save the shoots; whilst in other soils little or no damage is done by termites even when no treatment is adopted, and the amount of damage done does not always seem dependent merely on the presence of the insect concerned.

Indigo. In April, 1918, an investigation was commenced of the parasitization of the Indigo Psylla (*Arytaina isitis*). This study is only in its initial stages and only four months' figures are available, but three species of Chalcididæ have been obtained and of these one species is very common. The amount of parasitization was small at the beginning of April, but began to increase in the beginning of May and reached its highest (about 30 per cent.) at

Shoot of mulberry affected with "Tukra."

the end of that month, began to decline again in the third week of June and reached its lowest at the end of July.

Mulberry. The "Tukra" disease of mulberry, resulting in curling and malformation of the shoots and new leaves, has been known for a long time in Bengal, where it is sometimes bad, and a few affected plants have lately been found at Pusa also. An investigation of the cause of this disease was carried out during the year, and it was found by experiment that the curling and subsequent malformation of the shoots was due to the presence of a mealy-bug (*Pseudococcus*), and that, although two species of *Pseudococcus* are to be met with on mulberry, it is only one of these (as yet unidentified) which causes *tukra*. This mealy-bug becomes active at Pusa at the beginning of March and passes through a complete life-cycle in 24 days. The generations, however, overlap one another, and it is not infrequent to find nymphs, gravid females and pupæ or adult males on one and the same plant. The mature nymphs as well as the females are parasitized by three species of Chalcididæ, one of which keeps down the number of nymphs and females to a large extent. A Cecidomyiad fly (? *Coccodiplosis* sp.) larva has been found to attack the eggs, the fly maggots being found chiefly in the ovisacs of the mealy-bug and having been observed to suck the eggs dry. The larvæ of a Coccinellid beetle also attack the nymphs and females of this *Pseudococcus*.

As regards treatment of *tukra*, it was found that the practice of removing the affected shoots and burying or burning them was not effective by itself, as the nymphs hide themselves in the crevices of the unexpanded leaf-buds on the plants, and, as soon as these leaves expand, they in their turn become affected and the disease is continued. Removal of the affected shoots followed by thorough spraying with Fishoil-resin soap will probably prove more effective.

Fruit Flies. Over five thousand pupæ of the Peach Fruitfly were collected at Pusa in May, 1918, and kept under observation to see whether any would lie over until the

following year and to rear out any parasites. No pupa lay over and no parasites were reared.

Fruit Pests. Special attention was paid during the year to the pests of *Citrus* spp., jak (*Artocarpus integrifolia*), apple, pear, peach, nectarine, grape, guava, custard-apple and plantain. A large amount of information on Indian Fruit-pests has now been accumulated, and it is hoped to write this up when opportunity admits. The Gracilariad found on apple in North-West India and Assam has been identified as *Gracillaria zachrysa*, Meyr.

Life-histories of Insects. In the Insectary, besides the rearing of the various borers and rootfeeders of cane and rice already mentioned and which constituted about 100 lots, some 200 other lots of insects were reared and observations made on their life-histories and habits. Amongst these at least five new pests have come to light, *viz.*:—

(1) An unidentified Longicorn borer, C. S. 1645 (?*Nupserha* sp.) (Plate XIV, fig. 1), found in stems of *Vigna catjang* in August. It bores in the main stem and may attack the young plants. The bored stem swells to some extent, and, although in the majority of cases the plants are not killed, they are stunted and bear no fruit.

(2) A caterpillar found boring into young coconut fruits in the bunch on the tree and causing the young fruits to drop off. An accumulation of frass webbed up with silk indicates the presence of the borer. This insect is apparently an undescribed species of *Tirathaba* (Pyralidæ) (Plate XIV, fig. 2). It is interesting to note that *Tirathaba trichogramma*, Meyr., is also known to attack young coconut fruits in Fiji,[1] but this type of damage has never been noticed before in India so far as we are aware.

(3) *Calandra stigmaticollis* (Plate XV, fig. 1) is reported to kill large coconut trees in Ratnagiri by boring into the stem in which it breeds in large numbers. This is an interesting confirmation of a former record of this weevil attacking coconut in Malabar. In confinement it has been

[1] *Novitates Zoologicæ*, XXIV, 32.

EXPLANATION OF PLATE XIV.

Fig. 1. Longicorn boring *Vigna catjang* stem (C. S. 1645).

a, Stem of *Vigna catjang* attacked by larva.
b, Larva, natural size and magnified ($\times 4$).
c, Pupa, „ „ „ „ „
d, Imago, „ „ „ „ „

Fig. 2. *Tirathaba* n. sp.

a, Young coconut fruit attacked by larva, showing frass ejected.
b, Larva, natural size and magnified ($\times 3$).
c, Pupa, „ „ „ „ „
d, Imago, „ „ „ „ „

PLATE XIV.

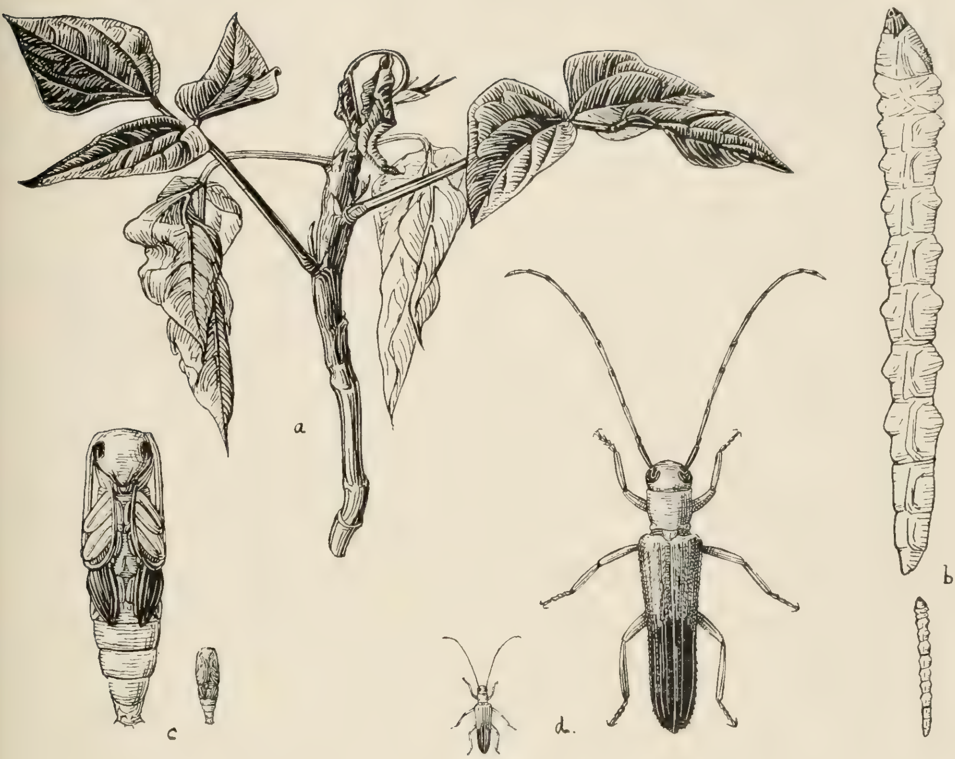


Fig. 1. Longicorn boring *Vigna catjang* stem (C. S. 1645).

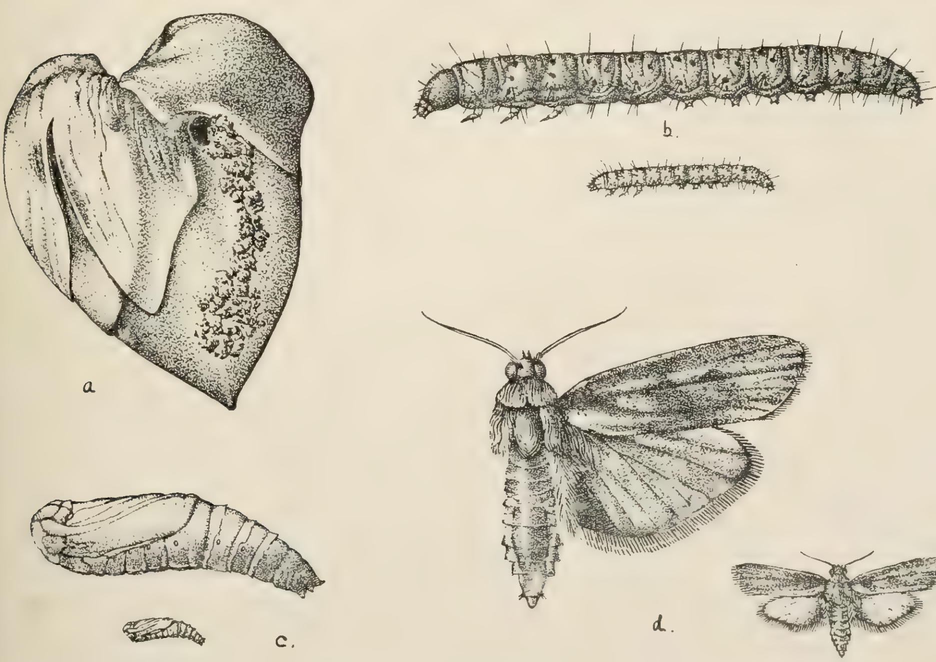


Fig. 2. *Tirathaba* n. sp.

EXPLANATION OF PLATE XV.

Fig. 1. *Calandra stigmaticollis* (C. S. 1752).

a, Portion of attacked coconut stem, showing larval galleries and larvæ *in situ.*

b, Larva, natural size and magnified (×11).

c, Pupa, ,, ,, ,, ,, ,,

d, Imago, ,, ,, ,, ,, ,,

Fig. 2. Longicorn beetle boring orange shoots (C. S. 1766).

a, Larva, natural size and enlarged (×5).

b, Pupa, ,, ,, ,, ,, ,,

c, Imago, ,, ,, ,, ,, ,,

PLATE XV.

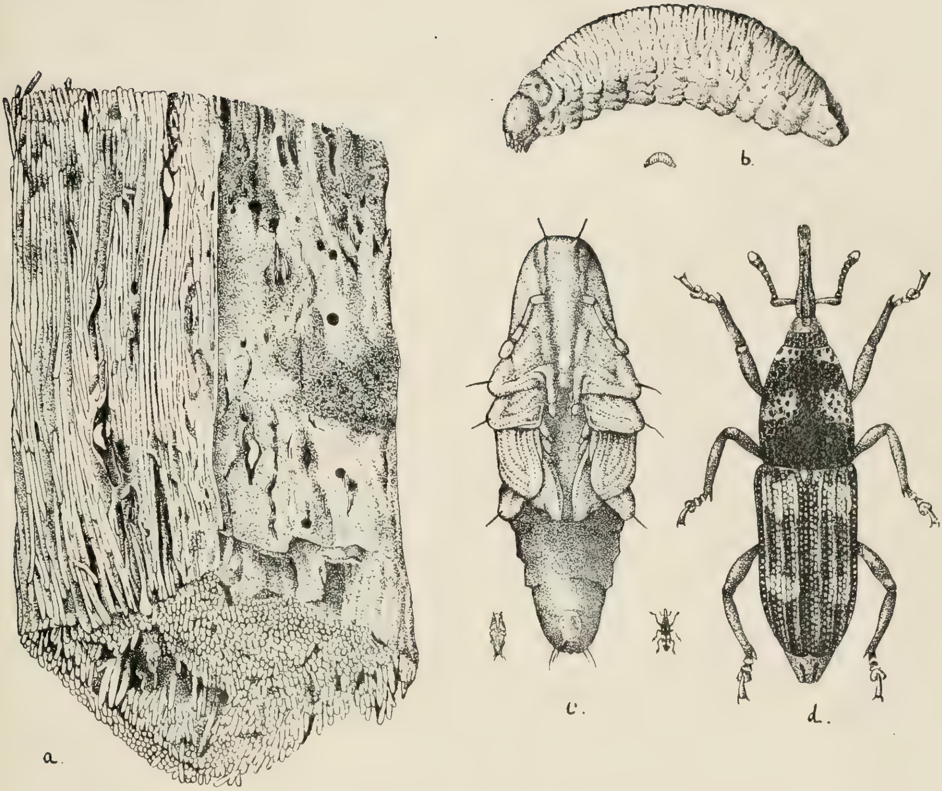


Fig. 1. *Calandra stigmaticollis* (C. S. 1752).

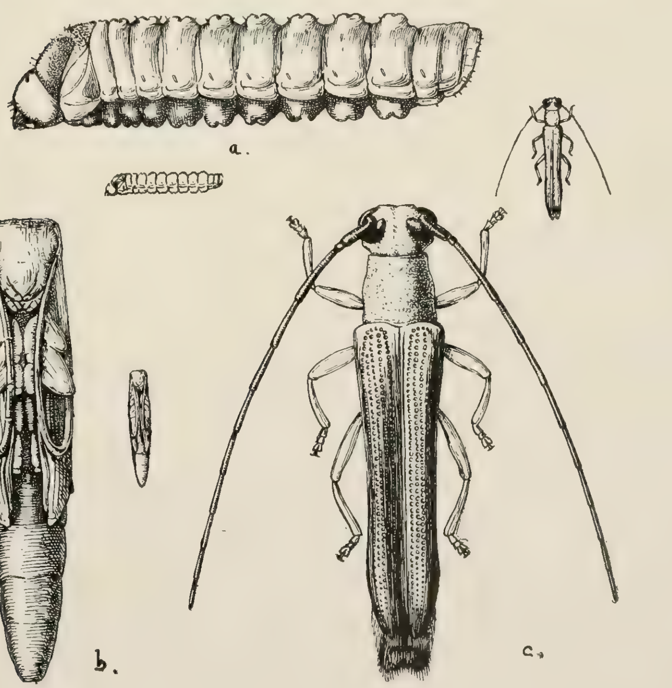


Fig. 2. Longicorn beetle boring orange shoots (C. S. 1766).

found that it is possible to rear this insect on sugarcane stems also.

(4) An unidentified Longicorn (Plate XV, fig. 2) was found boring and killing orange shoots in Sylhet. The grubs bore into the new shoots which appear in spring and cause them to wither.

(5) Eurytomine wasp in *Sesbania* pods. A small Eurytomine Chalcidid was observed to infest *Sesbania* pods at Pusa in September, 1917, and was kept under observation throughout the year. The eggs are laid in the green pods, the larvæ feeding on the seeds, almost all of which are destroyed. Pods infected when young do not develop any seed but shrivel up; in older pods the seeds are rendered useless, their contents being consumed. At the end of the season the damage in a small experimental plot amounted to about 90 per cent. Various remedial measures, such as deterrent spraying, were tried, but picking off the dry pods at frequent intervals gave the best results.

Investigations into the life-histories and habits of pests and other insects were continued. Brief accounts of the observations on the pests of sugarcane, rice and other main crops are given above under those crops. The more important points noted with regard to some of the other insects under rearing during the year are noted below :—

(6) *Amsacta moorei sara.* Hibernating pupæ were received from Dohad in May, 1917. In the Insectary at Pusa moths emerged from these up to 24th June, 1917. Eggs were obtained and a cycle observed; this took a full year, the pupal period extending from July, 1917, to June, 1918. This Gujarat form seems to be biologically distinct from the typical South Indian form *moorei*, but I have been unable to detect any morphological differences.

(7) *Eugnamptus marginatus* (Plate XVI, fig. 1). The salient points in the life-history were given in last year's Report. A point determined by subsequent observation is that the grubs sometimes remain underground in a resting condition for more than a year.

(8) *Agrotis ypsilon.* In a previous Report an account was given of the rearing of this insect under artificial conditions throughout the hot weather; successive broods were then obtained up to August, when the eggs failed to hatch. During the current year full-grown caterpillars were observed on 3rd September, 1917, feeding in an experimental plot of tobacco on the Farm. Eggs must have been laid in this tobacco plot during the first half of August. This insect is therefore capable of breeding in the Plains during the Rains, though whether the parents of these larvæ had bred in the Plains or were early migrants from the Hills remains uncertain.

(9) *Azygophleps scalaris* (Plate XVI, fig. 2). This year caterpillars were found here for the first time boring *Sesbania* stems. The moths appear in May, there being only one generation in the year, aestivation and hibernation taking place in the larval state.

(10) *Agromyza* sp. About fifteen acres of pea (*Pisum arvense*) grown alone and about seventeen acres grown intermixed with other crops were under observation during the Pea Stem-fly season. In both the plots about 0·4 to 0·5 per cent. of the pea plants were found drying up with external symptoms of Stem-fly attack, but closer examination showed that only about 8 per cent. of the drying plants were affected with the fly and that the loss of the remainder was not due to insect attack.

(11) *Ancylolomia chrysographella.* From further observations it seems evident that this is not usually a pest of rice around Pusa. A search over large areas revealed only a single larva in a dry seed-bed.

(12) *Cryptorrhynchus gravis.* This weevil causes serious damage to mango fruits in Eastern Bengal and Assam, the fruits being bored by the grub and rendered valueless. The damage done is very great, so much so that it is often difficult to find fruits which are unattacked. This pest was investigated at Dacca at the end of July, 1917, when more than three dozen adult weevils were found on a single mango tree, hiding amongst the roots of an epiphyte.

EXPLANATION OF PLATE XVI.

Fig. 1. *Eugnamptus marginatus* (C. S. 1457).

a, Mango shoot; an adult weevil (natural size) is seen cutting off a leaf for the purpose of ovipositing in the detached portion.

b, Larva, natural size and magnified (×8).

c, Pupa, ,, ,, ,, ,, ,,

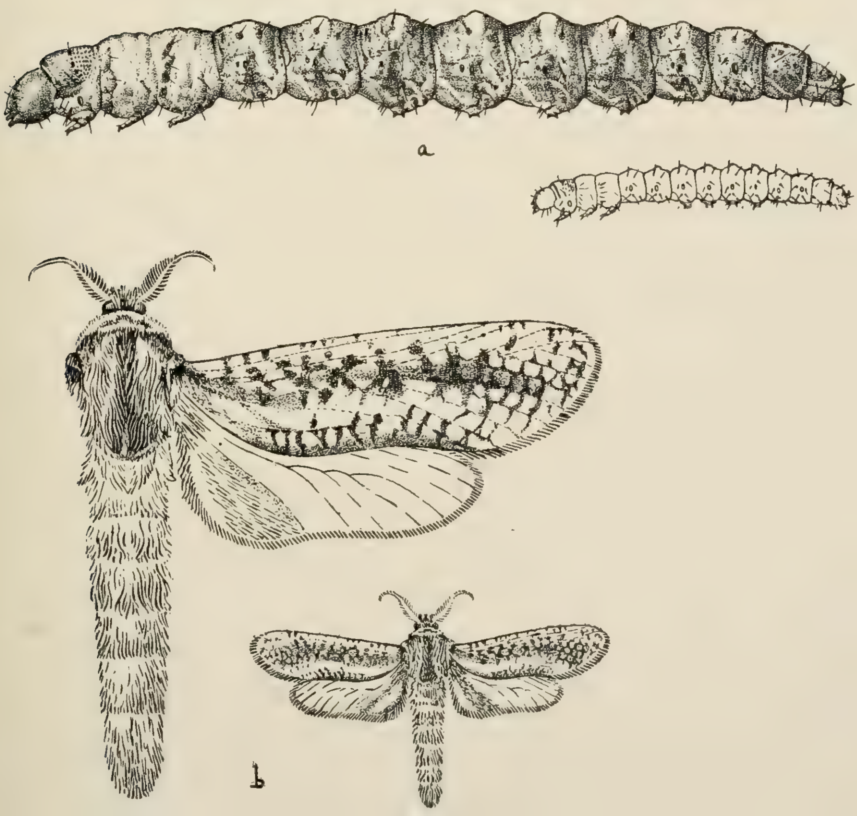
d, Imago, ,, ,, ,, ,, ,,

Fig. 2. *Azygophleps scalaris* boring *dhaincha* stem (C. S. 1807).

a, Larva, natural size and magnified (×3).

b, Moth, ,, ,, ,, ,, ,,

Fig. 1. *Eugnamptus marginatus* (C. S. 1457).



Further observations were made in June, 1918, in Sylhet, where isolated mango trees growing wild in the jungle as well as those cultivated in rather isolated portions and having hardly any epiphytes growing on them were found to be equally infected. In confinement at Pusa the adult weevils did not live beyond September, but it seems likely that in Bengal and Assam it may pass the winter as an adult. This pest requires close observation for a full year under field conditions to enable remedial measures to be suggested.

(13) The Longicorn borer (? *Oberea* sp.) in stems of *Phaseolus aconitifolius*, mentioned in last year's Report, has been observed to rest for two years in the larval state.

(14) *Odontotermes assmuthi.* Colonies were again established in tile nests from eggs laid by winged imagines, but we have been unable to carry them on beyond October, by which time the first-hatched eggs have become adult soldiers and workers.

(15) *Microtermes obesi.* After several failures in former years, colonies have this year been established in artificial nests. Eggs have been obtained from winged imagines and are hatching out at the time of writing this Report.

(16) The following insects have been observed to have only one generation in the year, *viz.*, *Anomala bengalensis*, *A. biharensis*, *Adoretus caliginosus*, *Cryptocephalus sexsignatus*, an unidentified Lamiad borer in *Saccharum* sp., and three unidentified lepidopterous borers in *Saccharum* spp.

(17) *Cosmopteryx phœogastra.* This was referred to in last year's Report under the name *C. manipularis*, but has since been differentiated and described by Mr. Meyrick in the *Entomologists' Monthly Magazine.* Larvæ mining bean leaves were collected in November, 1916, and were apparently resting at that time; they continued to rest and emerged in July, 1917.

(18) *Stictaspis ceratitina.* The maggots of this Fruit-fly were found in large numbers in July and August in new

bamboo shoots which were dying. Experiments undertaken to ascertain whether this fly was the direct cause of the death of the shoots were inconclusive.

(19) *Argyroploce paragramma* (Plate XVII, fig. 1). The larvæ of this Eucosmid moth were found to be very common at Pusa in July, boring into new bamboo shoots. Generally a great many caterpillars were found in the same shoot boring the stem, completely hidden under the protection of the leaf-sheaths. They seemed to be responsible for the death of a fair percentage of new shoots.

(20) *Nodostoma subcostatum* (Plate XVII, fig. 2). This Chrysomelid beetle had been known hitherto as a pest of plantain, nibbling the leaves and fruits. In October, 1917, it was observed to nibble the surfaces of young grape-vine leaves to such an extent as to kill the young leaves. The larvæ were found underground amongst grass-roots in July.

(21) *Balaninus c-album* (Plate XVIII, fig. 1). This weevil had been reared before from seeds of *Eugenia jambolana*, but little was known about it. This year observations were made to determine its real connection with the fruits. It has only one generation in the year. The adult weevils emerge in May and June, and feed on young green fruits by puncturing them with their snouts. The punctured fruits grow and ripen but the punctured spots on them do not grow and appear later on as so many pits in the ripe fruits; this is why the majority of ripe fruits are deformed in shape. The eggs are deposited in the fruits whilst the latter are still on the tree. The weevils appear in enormous numbers and by the time the fruits are ripe practically every seed harbours a grub. Later on, the grubs, when full-grown, leave the seeds and go into the ground and rest there until the next season. The obvious remedy is thorough destruction of the seeds.

(22) A white Mite occurred on the tender leaves of jute in the experimental plots of the Imperial Mycologist. The mites fed on the under-surfaces of the leaves which had a lacerated brownish appearance and were somewhat

EXPLANATION OF PLATE XVII.

Fig. 1. *Argyroploce paragramma* (C. S. 1631).

a, Bamboo shoot with outer sheathing leaves removed, showing bore-hole of larva.

b, Larva, natural size and magnified (×5).

c, Pupa, " " " " "

d, Imago, " " " " "

Fig. 2. *Nodostoma subcostatum* (C. S. 1719).

a, Grape-vine leaf eaten by beetles.

b, Beetle, natural size and magnified.

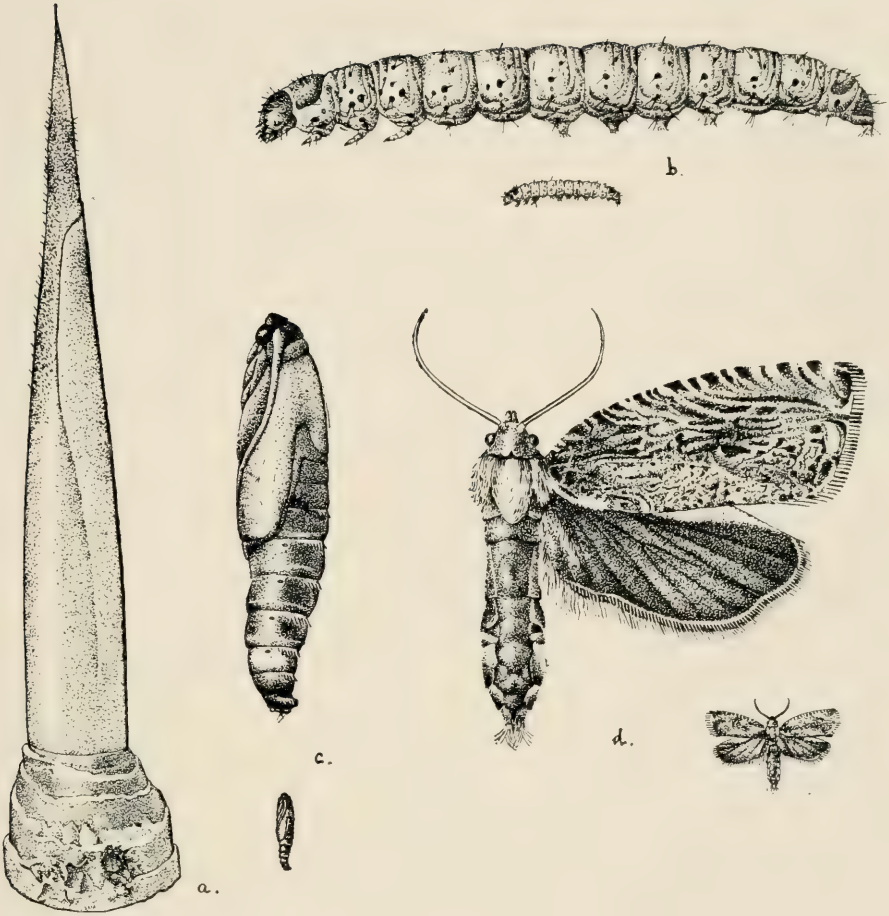


Fig. 1. *Argyroploce paragramma* (C. S. 1631).

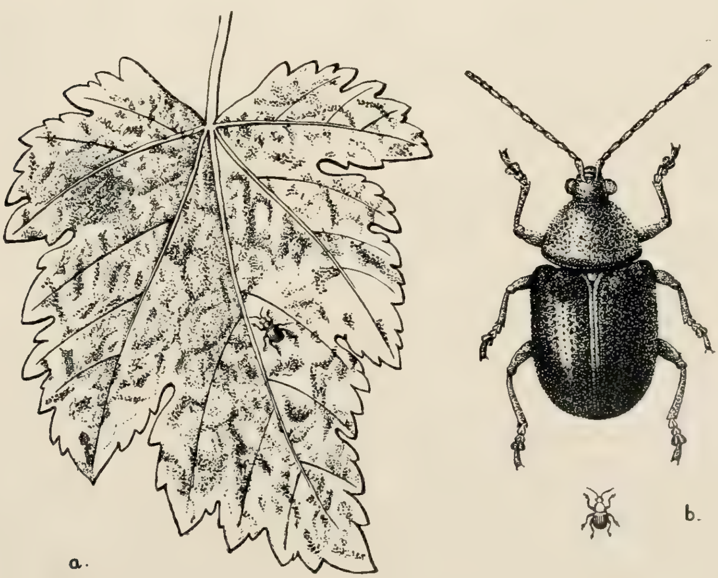


Fig. 2. *Nodostoma subcostatum* (C. S. 1719).

EXPLANATION OF PLATE XVIII.

Fig. 1. *Balaninus c-album.*

a, Immature fruits of *Eugenia jambolana* with adult beetles puncturing them (natural size).

b, Mature fruit of *Eugenia jambolana*, showing distortion and pits caused by punctures of *B. c-album* (natural size).

c, *Eugenia jambolana* fruit cut open, showing larva of *B. c-album* feeding inside the seed (natural size).

d, Larva, natural size and magnified (× 7).

e, Imago, magnified. (The natural size is shown in *a*.)

Fig. 2. *Belionota prasina* (C. S. 1720).

a, Larva, natural size and magnified (× 2⅓).

b, Pupa, ventral view, natural size and magnified (× 2⅓).

c, Pupa, dorsal view, magnified (× 2⅓).

d, Imago, natural size and magnified (× 2⅓).

PLATE XVIII.

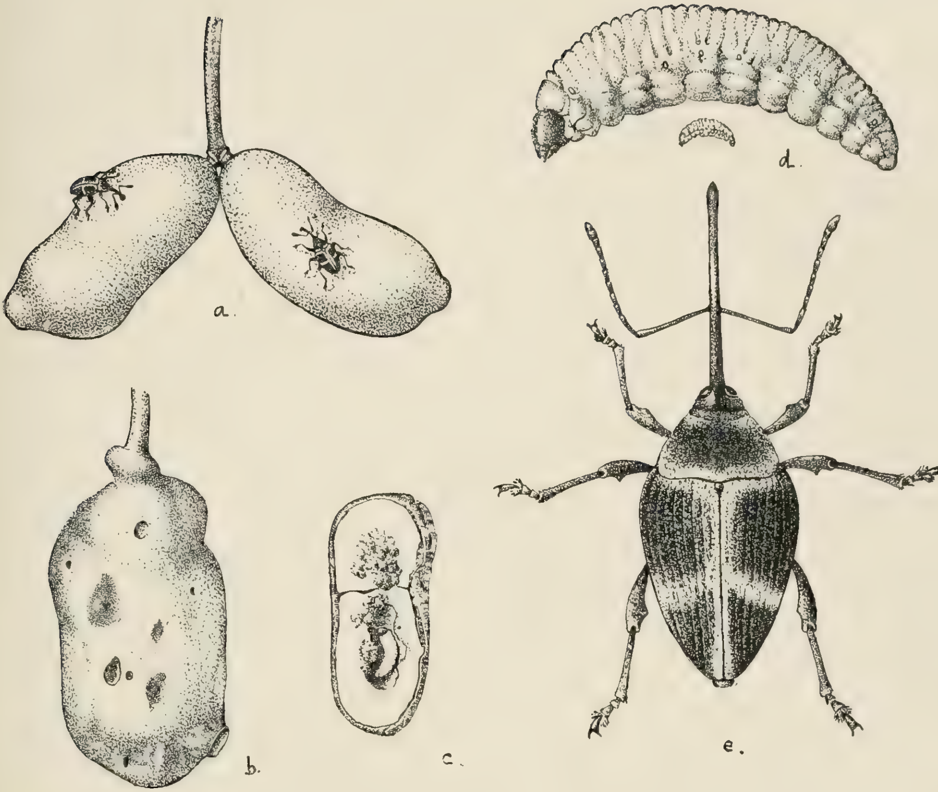


Fig. 1. *Balaninus c-album.*

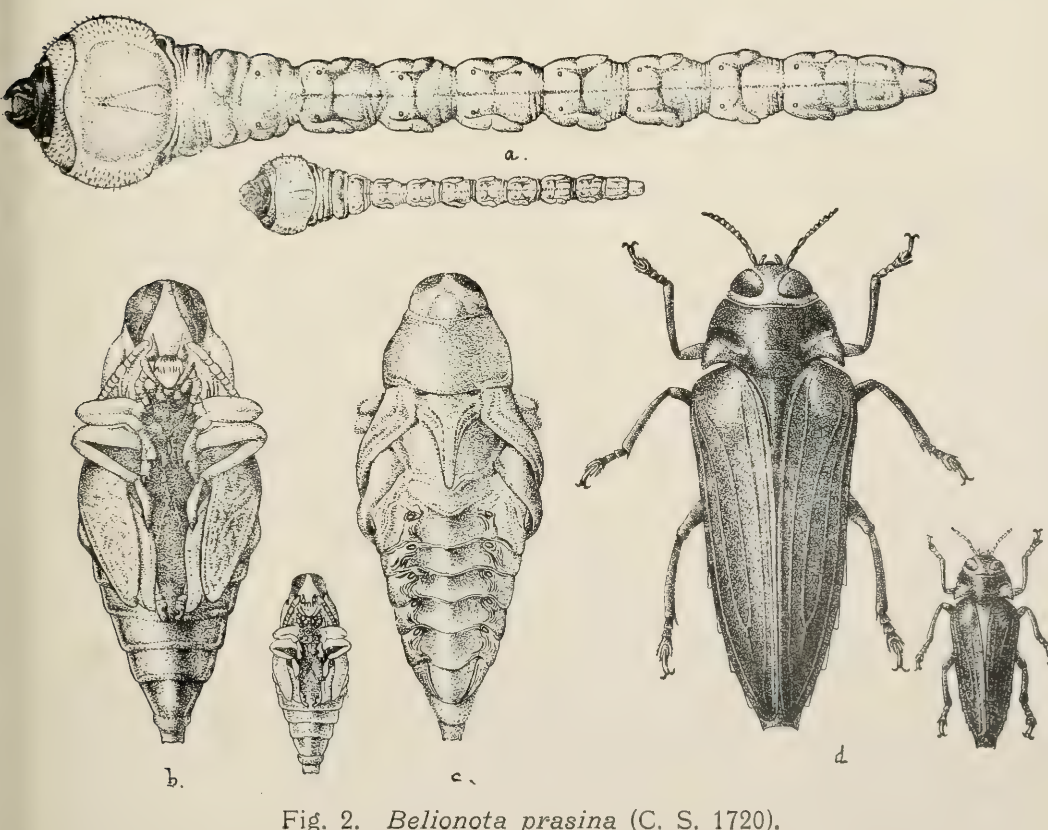


Fig. 2. *Belionota prasina* (C. S. 1720).

EXPLANATION OF PLATE XIX.

Fig. 1. *Alcides frenatus* (C. S. 1672).

a, Larva; natural size and magnified ($\times 5$).
b, Pupa, ,, ,, ,, ,, ,,
c, Imago, magnified ($\times 5$).
d, Mango shoot bored by larva, natural size.
e, Imago puncturing mango shoot, natural size.
f, Punctures made by adult weevil for feeding and egg-laying.
g, Hole of exit of adult weevil from mango shoot.

Fig. 2. *Giaura sceptica* (C S. 1659).

a, Larva, natural size and magnified ($\times 5$).
b, Cocoon, ,, ,, ,, ,, ,,
c, Pupa, ,, ,, ,, ,, ,,
d. Imago, ,, ,, ,, ,, ,,

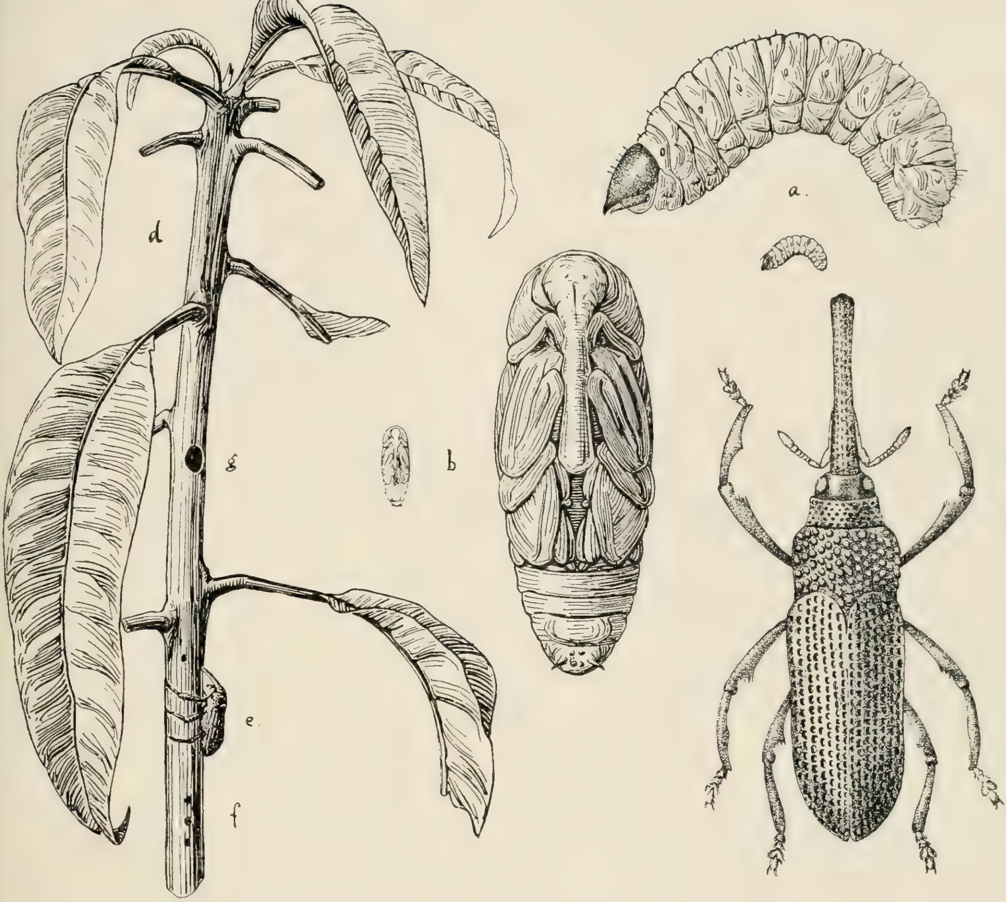
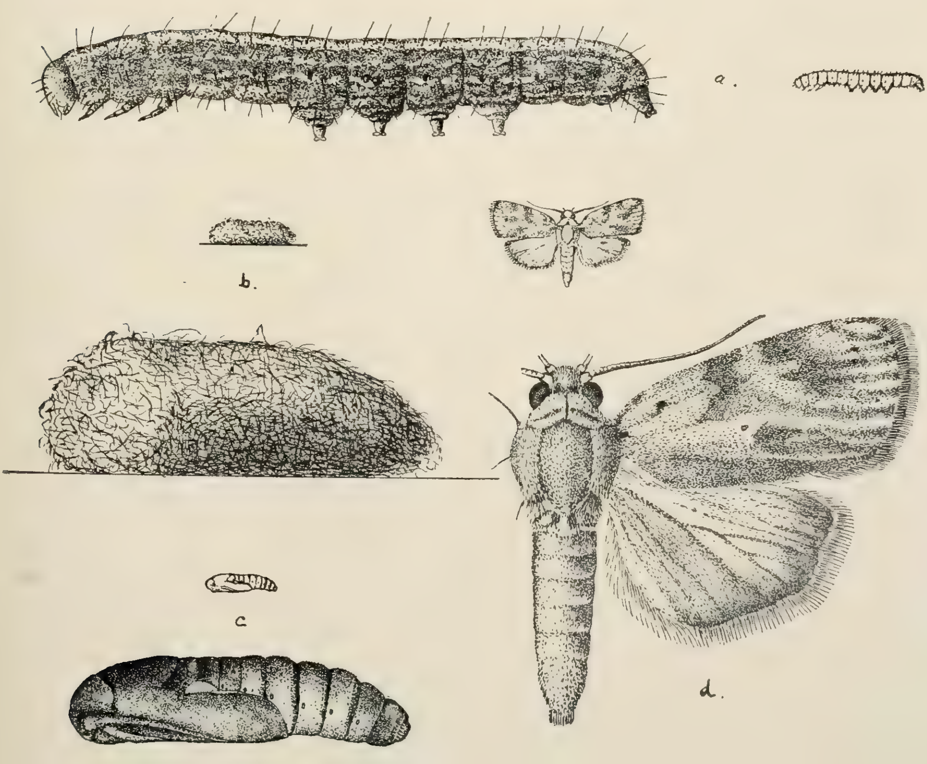


Fig. 1. *Alcides frenatus* (C. S. 1672).



crumpled longitudinally. Unlike Red Spider, there was no webbing. A single spraying with a spray composed of 1 lb. olene soap and six ounces of flowers of sulphur in 12 gallons of water proved effective.

(23) A species of Tingidid bug was noted to cause severe damage to *Bela* (*Jasminum sambac*) leaves at Bankura. Spraying with simple soap solution was effective.

(24) *Glyphodes caesalis* was observed to attack practically every fruit of jak throughout Sylhet, even large fruits not being immune. This insect is known as a jak-pest in Southern India, but has not been noted before as a pest north of the Madras Presidency.

(25) *Belionota prasina* (Plate XVIII, fig. 2). At Surat a dead mango tree was found to be full of the larvæ of this Buprestid beetle, and the death of the tree had apparently been caused by them. The larvæ were in various stages of growth and apparently represented more than one brood. The adult beetles began to emerge at Pusa in October, 1917, and continued to do so until April, 1918.

(26) *Alcides frenatus* (Plate XIX, fig. 1). This weevil was observed at Dacca in July as a pest of mango. Eggs are deposited in the shoots which are tunnelled by the grub, whose pellets of excrement are thrown out through small holes gnawed in the sides of the tunnel. Pupation takes place inside the burrow, the adult weevil gnawing its way out through a large hole of exit. The adult weevils are found pairing and ovipositing freely on the shoots.

(27) *Chlumetia transversa*. The larvæ have been found at Pusa tunnelling fresh mango shoots in a way very similar to that of *Alcides frenatus*, the frass being ejected exactly in the same manner.

(28) *Giaura sceptica* (Plate XIX, fig. 2). The larvæ of this moth were found in large numbers at Pusa in August rolling the tender leaves of velvet bean.

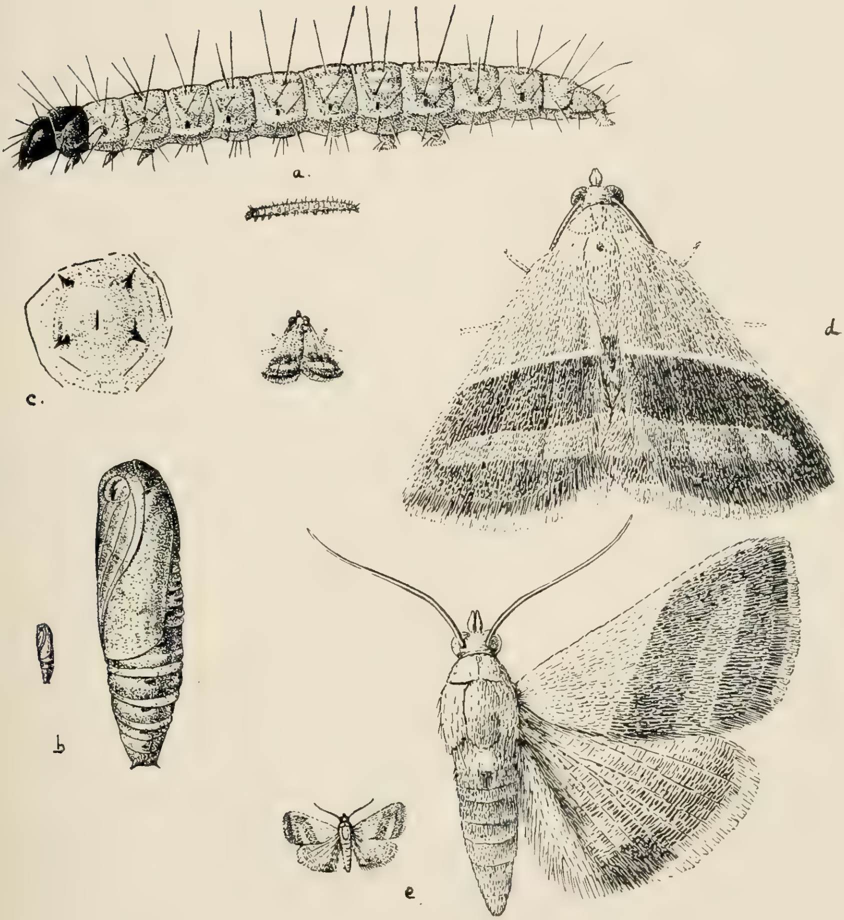
(29) Severe damage was observed to be caused to a crop of Mung (*Phaseolus mungo*) at Pusa in August by the

following, *viz.*, *Catochrysops cnejus*, *Anarsia ephippias*, *Eucosma melanaula* and *Eublemma hemirhoda* (Plate XX). *A. ephippias* and *E. melanaula* commenced the attack by rolling and damaging the tender top-leaves, and, when the crop began to flower, all four appeared and damaged the flowers. They continued their injurious activities when the pods formed, all the four boring into the pods and eating the seeds. *Eucosma melanaula* was also observed to cause similar damage to the flowers and pods of *Phaseolus aconitifolius* and also to damage the tender top-leaves of an experimental crop of Florida Beggar Weed.

(30) Quite appreciable damage was done in August to the new tender leaves of litchi by *Acrocercops hierocosma*, whose larvæ mined them, and by *Argyroploce leucaspis*, whose caterpillars rolled and nibbled them. The latter especially was very common.

Grain Storage Experiments. The storage experiments undertaken three years ago were concluded and an account of them will be written up. The method of storage under a layer of sand gave the best results, the grains and pulses remaining perfectly safe and in good condition. The straw granaries mentioned in last year's Report did not give as good results as had been expected.

The status of *Tribolium castaneum* was definitely determined during the year. It is essentially a pest of ground wheat (flour, *atta* and *suji*) and does great damage to these products, especially during the Rains, by imparting to them a characteristic nauseous smell and taste, which lowers their value as food and consequently also the price of infected material; in cases of bad infection, indeed, the flour may be quite uneatable. In order to determine its capacity for injury to sound wheat, *i.e.*, whole grains unaffected by *Calandra oryzæ* or *Rhizopertha dominica*, several thousand adults of *Tribolium castaneum* were confined in an earthen vessel with a quantity of wheat which, at the end of a year, was found to have been hardly damaged, although breeding on a small scale had taken place, as was evident from a few cast larval skins. This



Eublemma hemirhoda (C. S. 1649).

a, Larva, natural size and magnified (× 5).
b, Pupa, ,, ,, ,, ,, ,,
c, details of anal extremity of pupa, posterior view.
d, Imago, resting position, natural size and magnified (× 5).
e, Imago, natural size and magnified (× 5).

observation was also corroborated by the fact that the wheat obtained last year for storage experiments contained *Tribolium* when stored; but, in the samples which were unaffected by *Calandra* and *Rhizopertha*, no damage was done by *Tribolium*, whereas, in samples which were affected by *Calandra* and *Rhizopertha*, these two pests first produced wheat dust in which *Tribolium* could breed and it was only in these samples that *Tribolium* bred profusely.

For the first time, at least in the Pusa area, *Bruchus chinensis* and another unidentified[1] species of *Bruchus* were observed to breed in the fields in pods of cowpea (*Vigna catjang*), but only a few could be found after a good deal of search. Whilst *Bruchus chinensis* is thus shown to be capable of breeding in the field, it is essentially a pest of stored pulse, to which it causes serious damage.

Another unidentified[1] species of *Bruchus* was observed breeding in *Sesbania* pods in the field, and was kept under observation both in the Insectary and in the field. The beetles did not breed in the stored seeds and the emergence of the adults extended over a long period from February to June.

In last year's Report mention was made of an experiment to find out the effect of sunning pea (*Pisum arvense*) seeds affected by *Bruchus affinis*. Twenty-six pounds of pea seeds were taken from a crop harvested from a field known to be affected. Half of these were dried in the sun for seven days, when their weight was reduced to 12 lb. $9\frac{1}{2}$ oz.; the other half was kept as a check. After a period of a year, in the sunned sample the damage was one-third of that in the untreated sample. Thus, although damage was not entirely prevented, it was checked to a very large extent.

Insecticides. Incosopol, a contact insecticide manufactured by the Indian Cotton Seed Oil Company, Navsari, was tested on Aphids, Scale-insects and Mealy-bugs, and

[1] A collection of the various Bruchid beetles reared from pulses was sent out during the year for identification but the names had not been received at the time of writing this Report.

in every case gave satisfactory results. Two grades were tested, of which that known as No. 2 gave much better results than did No. 1. Resin Compound, Fishoil-Resin Soap, and Incosopol No. 2 seem all about equally effective insecticides against Aphids, Aleyrodids, Scale-insects and Mealy-bugs, which are common garden pests; Fishoil-Resin Soap and Incosopol No. 2 can be safely recommended as they cause no injury even to tender foliage.

Against the common house Cockroach (*Periplaneta americana*) infesting a godown trials were made of a mixture of Boracic Acid in honey. In an experiment in the Insectary adults as well as nymphs fed greedily on this mixture; after the second day they began to pass liquid excreta and the nymphs died off in the course of five days; the adults, however, resisted longer, not dying even on the eighth day, but by that time they were certainly very sick, unable to walk and lying on their backs. Boracic Acid, though effective, is therefore a very slow poison to these insects. In a house they may be trapped in numbers in an open-mouthed kerosine tin in which is placed a quantity of weak solution of *gur* (molasses) in water; the adults are attracted and drop into the *gur* solution and appear unable to escape.

Protection of wood against Termites. Simple experiments in the protection of wood against Termites (so-called " White Ants ") have been in progress since 1910, the termite utilized being *Microtermes obesi*. The name of the species concerned is given here because different species of termites have different habits and tastes, facts which are usually overlooked in carrying out similar experiments. Some kinds of timber may be more or less immune to attack by the local termites in one district, yet the same kinds of timber may be greedily attacked by other species of termites in another district. Our experiments have shown also that any particular method of treatment does not produce the same deterrent effect in all varieties of wood. The deterrent effect depends on (1) the treatment employed, (2) the variety of wood treated, and (3) the kind

of termite against which protection is sought. Under conditions *at Pusa* we have found that teak, sissoo (the red heart-wood), and jarrah naturally resist termite (*M. obesi*) attack without any treatment, and that, in the case of other woods subject to attack, treatment, whatever be the reagent used, in every case gives better results than no treatment. Wood can be rendered immune by impregnating it with (1) arsenicals or (2) creosote or wood-tar or some similar liquid, and the wood will remain immune as long as the arsenic is not dissolved out or as long as the smell of creosote, etc., is present. In actual practice treatment of wood with arsenicals is not easy without employment of a pressure apparatus, as it is difficult to get sufficient arsenic into the wood to preserve it for any length of time. Treatment with creosote, etc., however, is quite simple, as the desired results can be obtained by repeated paintings or by dipping in the preservative those parts of the timber which are to remain exposed to attack; although even in these cases, the use of a pressure apparatus to increase the amount of preservative taken up by the wood will considerably prolong the period of protection. For the ordinary person, however, who can only paint or dip woodwork likely to be attacked by termites, the use of creosote will usually give the best results, especially for underground woodwork.

Lantana Work. This work was taken up in November, 1916, on instructions from Government and has for its object the collection of information regarding the occurrence within the Indian Empire of any insects which may be utilized as efficient checks on the growth of *Lantana*. With this object Mr. Y. Ramachandra Rao, M.A., Entomological Assistant in Madras, has been placed on special deputation under the Imperial Entomologist, and during the year under Report worked in Southern India, Burma and Assam. A very large number of insects has been found to occur on *Lantana* but most of these appear to be merely casuals, not confined to *Lantana* but very polyphagous in their habits, or of no importance as checks on *Lantana*. This investigation is still in progress.

IV. Bees, Lac and Silk.

Bees. The experiments with the Indian Bee (*Apis indica*) were continued. There is, however, nothing of special interest to record.

Advice and help was given during the year to various bee-keepers in India.

A note was written and submitted to Government on the adulteration of beeswax in India.

Lac. Emergence of lac larvæ took place at Pusa on 12th October, 1917, for the winter brood, and on 20th June, 1918, for the summer one. Forty trees were inoculated in October-November and sixty trees in June. Brood-lac was supplied to various inquirers, and numerous inquiries regarding lac were dealt with during the year. No students attended the lac courses during the year. An article on the present position of the Lac Industry in India was written for the *Agricultural Journal of India.* This year it was found that, besides the species of *Eublemma* and of Chalcididæ which normally damage lac whilst on the trees, considerable damage was done to Ber (*Zizyphus jujuba* brood-lac by *Holcocera* (*Hypatima*) *pulverea* (Blastobasidæ). The larvæ of this moth usually damage scraped and unwashed stick-lac in store, but do not damage the growing lac as a rule.

Silk. The establishment of the silk-house, which is on a temporary footing, has been extended up to 31st March, 1919. Large numbers of broods of both mulberry and eri worms have been under rearing during the year, and the work of crossing the races of the mulberry worm has been continued with the object of producing a superior fibre. The multivoltine mongrel races, which we have already succeeded in establishing, continue to yield more and better silk than the indigenous multivoltine races. Eggs of some of these races have been distributed on a small scale to practically all silk centres throughout India, for trial under local conditions there, and the reports received, with the exception of that from the Superintendent of Sericulture, Berhampore, show that satisfactory results have been

obtained from these rearings. It is not yet, however, considered advisable to distribute the eggs of these races on a large scale until we are quite certain that they will not degenerate later on. At present we have twenty different mongrel races under rearing and are carefully recording the results in each case.

Numerous inquiries concerning rearing, reeling, dyeing, bleaching and spinning were dealt with during the year. Silk samples and bulletins on silkworm rearing were distributed to many applicants. Silk exhibits were sent during the year to the following :—(1) Madras Exhibition of Indian Arts and Industries (Diploma of Merit awarded), (2) Exhibition of Foods and Household Requisites, Bombay (Certificate of Merit), (3) Banjetia, Bengal, (4) Gwalior (Gold Medal), (5) Gujranwala (Gold Medal), and (6) Gorakhpur (Certificate of Merit). All the operations in sericulture from the egg to the finished product were exhibited in Madras and Gwalior, and these were much appreciated by the visitors to these Exhibitions. Eri, muga, tasar and mulberry silkworm show-cases were supplied to the Superintendent of Sericulture, Berhampore, Bengal.

Silk pieces and castor seed to the value of Rs. 884-0-5 were sold during the year and the sale proceeds credited to Government.

The Pusa silk-twisting machine, on which about one pound of mulberry, muga or tasar thread can be twisted by one boy or woman in one day of eight hours, was sent to Berhampore (Bengal) for exhibition purposes. This is believed to be an improvement on former local methods of silk-twisting. A silk merchant at Berhampore, who is supplying silk to the Home Industry Association of Calcutta, is twisting cotton and matka (handspun waste mulberry silk) on it, and is satisfied with the working of the machine; with this coarser thread one seer (two pounds) can be twisted in an eight-hour day.

Large quantities of mulberry seeds and mulberry silkworm eggs were supplied to the Agricultural Department

in Mesopotamia. Eri seed cocoons were sent to the Entomological Department, Egypt, where the worms are being reared successfully, to the Department of Agriculture in Mauritius, and to the Salvation Army for sending to East Africa. Eri and mulberry silkworm eggs were supplied to 84 and 85 applicants respectively, and mulberry seeds and cuttings and castor seeds were supplied to 14 applicants. Univoltine eggs of French and Japanese races, and Japanese bivoltine eggs, were sent to Guindy, Shillong and Muktesar for cold storage, and were successfully reared at Pusa in October, 1917, and March, 1918. Eggs of two Chinese univoltine races were received from the Salvation Army, Simla, and were successfully reared.

Seven students completed short courses in sericulture during the year and three students remained under training at the close of the year. Of the seven who completed their courses one came from Travancore, one from the Salvation Army Silk School at Bangalore, one from Bengal, and two each from Bihar and Indore.

A Second Report on the Experiments carried out at Pusa to improve the Silk Industry in India and a pamphlet on the anatomy of the silkworm and moth were published during the year; a Bengali translation of the former is in the press and one of the latter was published in the *Krishi Sampada* of Dacca.

V. Illustrations.

Coloured plates illustrating the life-histories of the following insects were prepared during the year, *viz.*, *Pseudococcus* sp. causing *tukra* disease of mulberry, *Ophideres materna*, *Cryptorrhynchus gravis*, *Platyptilia pusillidactyla* and *Eretmocera impactella*. Drawings in black-and-white, showing life-histories in more or less detail, were prepared of about seventy of the insects reared in the Insectary, and about the same number of other drawings of insects were also done.

Thirty-four new coloured plates of pests were issued in the *Report of the Proceedings of the Second Entomological*

Meeting, published during the year. No new coloured plates were printed during the year, but there is an ever-increasing demand for the plates already available.

The issue of coloured lantern-slides of insect pests has been continued as far as possible but only under considerable difficulties regarding the preparation of these slides. As there is a considerable demand for these slides on the part of the Provincial Agricultural Departments, every endeavour will be made to arrange for their preparation and supply.

VI. Miscellaneous.

Correspondence. A total of 114 parcels of specimens, mostly of crop-pests, was received during the year for identification and advice, whilst 911 letters were received and 1,221 issued, but all these numbers are exclusive of a large amount of routine correspondence, which every year becomes more and more onerous and takes up time which should be devoted to more scientific work.

VII. Insect Survey.

Steady progress has been made in additions to, and arrangement and identification of, the collection which continues to grow so that the question of space will become pressing in the near future. Temporary ease has been obtained by the removal of the Lepidoptera to a new room, 30×30 feet, but there is no further room for expansion in the present building. Keeping the collection in boxes in open racks, as has been done hitherto, has the serious disadvantages of exposing the specimens to risk of damage owing to the climate at Pusa and also of occupying an unnecessary amount of space; storage in cabinets or in double-sized store-boxes kept in closed almirahs would considerably improve the conditions of preservation of the specimens and also economize space. In this connection it may be of interest to compare the growth of the collections during the last ten years. It is not practicable to

take a census of the total number of specimens, which would run into hundreds of thousands, or to consider the unnamed and unsorted material, but, taking the definitely named species, we obtain the following figures :—

Order	1908	1910	1918
Hymenoptera	400	419	758
Diptera (excluding disease-carriers) .	...	...	168
Lepidoptera	600	1,235	2,540
Coleoptera	650	1,236	1,939
Rhynchota	500	606	743
Neuroptera (*Sensu antiquo*) . .	1	60	180
Orthoptera (*Sensu antiquo*) . . .	70	91	143
Totals . .	2,221	3,647	6,471

The staff required for the upkeep (which includes the sorting and identification, as well as the mere preservation, of the many thousands of specimens received every year) has not been increased during this time, although it will be seen that the work is constantly expanding and has already become very heavy, although this is only one branch of the activities of the Entomological Section. The War has interfered considerably with the transmission of specimens for identification, but the following collections have been sent out to specialists in the groups named and our thanks are due to them for the ready help afforded :—

(*i*) Microlepidoptera to Mr. E. Meyrick, F.R.S. Named and returned. The descriptions of numerous novelties have been published in *Exotic Microlepidoptera.*

(*ii*) Diptera to Mr. E. Brunetti. Mostly named and returned.

(*iii*) Rhynchota to Mr. W. L. Distant. Numerous novelties have been described in his recently issued seventh volume in the *Fauna* series, but the specimens have not been returned as yet.

(*iv*) Cicindelidæ to Mr. S. W. Kemp. Not yet returned.

(*v*) Aquatic Rhynchota to Mr. C. A. Paiva. Not yet returned.

(*vi*) Aculeate Hymenoptera to Mr. R. E. Turner. Returned named, and descriptions of novelties published in an Entomological Memoir and in the *Annals and Magazine of Natural History.*

(*vii*) Dryinidæ to Mr. J. C. Crawford, Washington.

(*viii*) Psyllidæ to Mr. D. L. Crawford, California.

(*ix*) An Aphid forming galls on *Rhus semialata* to Mr. A. C. Baker, Washington.

(*x*) Muscid flies affected with *Empusa muscae* to Mr. H. T. Gussow, Ottawa.

(*xi*) *Paruscanoidea* sp. (Chalcididæ), parasitic on eggs of *Hilda bengalensis,* to Dr. L. O. Howard, Washington.

(*xii*) A large consignment of *Microbracon* spp., parasitic on Cotton Bollworms, sent to Professor C. T. Brues, was unfortunately lost owing to enemy action. This loss was particularly unfortunate as this sending contained some very valuable material which it will take a long time and much work to replace.

(*xiii*) Ichneumonid parasitic on *Pseudagenia blanda* to Mr. C. Morley. Named as *Gotra longicornis* and returned.

(*xiv*) Carabidæ to Mr. H. L. Andrewes. Not yet returned.

(*xv*) Bruchidæ to Dr. G. A. K. Marshall. Not yet returned.

(*xvi*) Hispinæ and Cassidinæ to Mr. S. Maulik. Not yet returned.

(*xvii*) Odonata (part) to Major F. C. Fraser. Not yet returned.

The following collections sent out in previous years have not yet been returned:—

(*xviii*) Histeridæ to Mr. G. Lewis.
(*xix*) Longicorn beetles to Dr. Gahan.
(*xx*) Anthribidæ to Dr. K. Jordan.
(*xxi*) Rhynchota to Mr. W. L. Distant.
(*xxii*) Tettigidæ to Dr. J. L. Hancock.

Various collections of Indian insects have been received and named and returned as far as possible. These included collections sent by the Provincial Agricultural Departments and by numerous correspondents.

VIII. Programme of Work for 1918-19.

Major.

This will follow generally on the lines of work of the current year and will include general investigations of crop-pests and especially of the pests of sugarcane, rice and cotton, of fruit-trees, of stored grain, and of insects affecting *Lantana.*

Minor.

Results in various lines of work require to be written up and published as far as possible. Work and experiments in silk, lac and bee-keeping will be continued, and new insecticides and insecticidal methods tested as occasion arises. Systematic work on Indian insects will be carried out with our own resources and the help of specialist correspondents. Advice and assistance will be given as far as possible to Provincial Departments and to all inquirers on entomological subjects.

IX. Publications.

The following publications, either written by the Pusa staff or based on material sent from Pusa, have been actually issued during the year:—

Bagnall, R. S. . . Brief Descriptions of new Thysanoptera. IX. (*Ann. Mag. Nat. Hist.* (9), I, 201-221.)

Bagnall, R. S. .	. On two species of *Physothrips* (Thysanoptera) injurious to tea in India. (*Bull. Ent. Res.*, IX, 61-64, 2 figs.)
Crawford, D. L.	. Philippine and Asiatic Psyllidæ. (*Phil. Journ. Science*, vol. XII, sect. D, 163-174, 1 tab.)
De, M. N. .	. Anatomy of Silkworm and Moth. (Grihastha Publishing House, Calcutta.)
De, M. N. .	. Second Report on the Experiments carried out at Pusa to improve the Mulbery Silk Industry, compiled under the direction of the Imperial Entomologist. (*Agricl. Res. Inst., Pusa, Bull.* no. 74, pp. 28.)
Distant, W. L.	. Rhynchota, Vol. VII. Homoptera; Appendix. Heteroptera; Addenda. (*Fauna of India Series*, pp. 210, 90 figs.)
Fletcher, T. Bainbrigge.	*Icerya purchasi* in Ceylon: A warning to India. (*Agricl. Journ., India*, XII, 525-531, tab.)
Fletcher, T. Bainbrigge.	Report of the Proceedings of the Second Entomological Meeting held at Pusa on the 5th to 12th February, 1917. Pp. xii+340, 34 col. tabs.; Government of India Press.
Fletcher, T. Bainbrigge.	Agricultural Entomology. (*Annual Report, Board Sci. Advice for India*, 1916-17, pp. 78-95, 149-158.)
Marshall, G. A. K.	. *Platymycterus*, a new genus of Asiatic Curculionidæ. (*Ann. Mag. Nat. Hist.* (9), I, 245-252.)
Meyrick, E. .	. Exotic Microlepidoptera, vol. II, parts 2-5, pp. 33-160.
Meyrick, E. .	. Two new Indian species of *Cosmopteryx*. (*Ent. Mo. Mag.*, LIII, 257-258.)
Misra, C. S. .	. The present condition of Lac Cultivation in the Plains of India. (*Agricl. Journ., India*, XIII, 405-415, tab. 23, 1 map.)
Ramachandra Rao, Y.	Notes on some South Indian Cecidomyiids causing galls in grasses. (*Journ. Asiat. Soc., Bengal*, n. s., XIII, 299-306, tab.)

Turner, R. E. . . Notes on Fossorial Hymenoptera, XXXV. On new Sphecoidea in the British Museum. (*Ann. Mag. Nat. Hist.* (9), I, 356-364, fig.)

REPORT OF THE IMPERIAL PATHOLOGICAL ENTOMOLOGIST.

(F. M. Howlett.)

I. Introduction.

I was in charge of the Section for 10 months of the year, from August 28, 1917, when I returned from military duty in England. From 1st July to 27th August, 1917, Mr. T. Bainbrigge Fletcher, Imperial Entomologist, was in charge of this Section in addition to his own duties.

The greater part of the work of the Section during this period may be put under four main heads, work under each head being done chiefly by the officers named against each :—

(1) Mr. P. G. Patel. Observations on the life-histories and habits of blood-sucking and saprozoic insects.

(2) Mr. H. N. Sharma and the Imperial Pathological Entomologist, with M. Shaffi and M. Karim. Experimental and practical work on mosquitos.

(3) Mr. S. K. Sen and the Imperial Pathological Entomologist. Experimental work on insect psychology in relation to feeding and oviposition.

(4) The Imperial Pathological Entomologist. Experimental and practical work on insect-repellants and insecticides.

II. Blood-sucking and Saprozoic Insects.

Attention was chiefly directed to the comparative study of the habits of the larvæ of Tabanidæ, which show marked and interesting differences in the various species, and to working out the life-histories of the Pusa midges (genera *Culicoides* and *Ceratopogon*), a group of minute blood-sucking insects of which very little is known. The main features of several of these life-histories have been ascertained and illustrative coloured plates prepared, the

eggs and aquatic or semi-aquatic larvæ showing somewhat unusual characteristics. In view of the possibility that these flies may convey disease, observations on this curious and little-known group will be continued.

III. Experimental and Practical Work on Mosquitos.

Practical anti-mosquito work has consisted in the continuance of the mosquito campaign in Pusa. So far, with the aid of a very limited temporary staff, this work has, I think, sufficiently justified itself to warrant an extension on the "trap-breeding" lines first advocated by me in connection with the *Stegomyia* investigation of a few years ago. The main idea of trap-breeding is to supplement the ordinary (and almost inevitably incomplete) destruction of natural breeding-places by supplying a large number of alternative breeding-places of a suitable type which will absorb the local egg-supply, but which are in one way or another kept under control so that none of the eggs laid in them shall reach maturity.

The method has now been tried in various parts of the world and seems to have proved uniformly successful. It enables one materially to economize energy in reducing the mosquito population, and minimizes the difficulties associated with imperfect inspection and the discovery by the mosquitos of unnoticed or inaccessible breeding-places, this latter being the main and frequently unavoidable difficulty of the purely destructive methods generally advocated.

Proposals are being submitted for the construction of a number of permanent breeding-places in order to extend the work on the above lines, most of the breeding-places would take the form of small ornamental fishponds inspected and stocked with suitable local fish by the campaign staff.

A certain number of organic compounds have been tested as larvicides, but no results of any practical interest have been obtained except in the case of the Xanthates, which have a very high toxicity for mosquito larvæ.

A long series of experiments has been carried out with the object of ascertaining the factors which influence mos-

quitos (especially *Stegomyia scutellaris*) in their choice of breeding-places, and the deterrent or attractive effect of dilute solutions of a number of chemical substances as compared with pure water.

The results at present obtained indicate that—

(1) Temperature has a definite influence, eggs being laid more freely in warm water.

(2) Various chemical compounds have a deterrent effect when dissolved in small quantities ($\frac{1}{2}$-1 per cent.) in the water.

(3) A few chemical substances (especially sodium citrate and tartrate) have an attractive effect, a far larger number of eggs being laid in dilute solutions of these substances than in pure water.

This work is being continued, in conjunction with experiments on the effect of dilute solutions of chemical compounds on the development of mosquito larvæ.

IV. Insect Psychology in relation to Feeding and Oviposition.

A good deal of work has been done in this direction, but the results are not of a kind to be profitably discussed in a report of this nature.

One immediate outcome of them was the series of experiments on the egg-laying of mosquitos mentioned in the preceding section, and they have had a direct bearing on the work in connection with repellants.

V. Insect Repellants and Insecticides.

The subject of repellants and insecticides is one to which I have given much personal attention in the course of the last four years, and since my return from England I have continued experiments on repellants, and have attempted to devise standard methods for testing repellants and insecticides which will give a reliable index of their actual practical value.

Practical work in this connection, in collaboration with Captain Pool, A.V.C., was undertaken at the instance of

the Surra Committee meeting at Simla in May. This work has for its object the discovery of a repellant, limited as regards cost, which shall effectively prevent Tabanidæ from attacking camels, and so help to check the spread of surra among transport and other animals.

Through the kindness of the Inspector-General of Forests and the officers of the Forest Department at Dehra Dun, arrangements have been made to carry on the work in the laboratories of the Forest Research Institute, and it is still in progress.

VI. Programme of Work for 1918-19.

The most probable *main lines of work* are—

(1) General methods of insect-control.

(*a*) Attempts to ascertain the nature of the reactions which determine the processes of feeding, pairing, and egg-laying in insects.

(*b*) The direct effect of certain physical and chemical conditions or agents on the above reactions, more particularly with reference to disease-carrying insects.

(*c*) The physiological action of insecticidal and deterrent substances.

(2) General bionomics of insects and Arachnids which suck blood or otherwise cause disease in man or animals.

(3) Special work on surra-prevention, undertaken at the instance of the Surra Committee, in collaboration with officers of the A.V.C.

(4) Investigation of methods for combatting mange in transport camels, in collaboration with the military authorities.

VII. List of Publications.

Sen, S. K. . . . Beginnings in Insect Physiology and their Economic Significance. (*Agric. Journ. of India*, vol. XIII, pt. IV.)

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST.

(C. M. Hutchinson, B.A.)

I. Administration.

I held charge of the Section throughout the year.

Mr. J. H. Walton, Supernumerary Agricultural Bacteriologist, continued to be on military duty throughout the year.

II. Training.

Mr. S. N. Bose, Bacteriological Assistant to the Agricultural Chemist to the Government of Bengal, was under training in this Section from 3rd January, 1916. He finished his course and was relieved from this Section on the 6th January, 1918.

Mr. Kripa Ram, a student from Punjab, was under training, specially in media preparation, in this Section for a short period from 25th September to 18th October, 1917.

Mr. P. C. Chaudhury, Superintendent of Sericulture, Bengal, was under training in bacteriological technique in connection with the silkworm disease, from 6th to 17th December, 1917, and 6th to 19th February, 1918.

Mr. K. L. Mahta, a student from Kashmir State, was under training in the microscopic technique in connection with the silkworm disease, from 15th March to 30th June, 1918.

Work was done on the following subjects :—

III. Soil Biology.

Nitrification. Further observations were made as to the conditions determining maximum nitrification in various types of Indian soils Field observations of the seasonal variation and the effect of cropping and of fallow were continued. It was found that the presence of a crop,

whilst diminishing the apparent amount of nitrification as measured by the nitrate found in the soil, actually increased the amount if it is assumed that the crop takes its nitrogen entirely as nitrate.

In connection with nitrification studies, further observations were made as to the formation of bacterio-toxins in soils, and a paper on this subject was read at the fifth session of the Indian Science Congress at Lahore.

Nitrogen fixation. The First Assistant continued his experiments upon the specific nature of various strains of *B. radicicola* and upon apparent symbiotic fixation of nitrogen without nodule formation in the case of inoculation with foreign strains. Clear evidence of activation of growth by non-symbiotic nitrogen fixation both by azotobacter and nodule organisms was obtained. These observations will form the subject of a paper now in course of preparation.

Green-manuring. The field trials arranged in collaboration with the Imperial Agriculturist were continued on the experimental area of the farm; they are designed to test the field value of the modified method of green-manuring described in *Bulletin 63, Agric. Res. Inst., Pusa;* the increased returns obtained on the *rabi* (winter) crop, although considerable, are not a measure of the practical value of this method which depends largely upon its sustained and residual effect. This has been well illustrated in the various crops on the experimental area of this Section, which have given consistent increases of some 30—60 per cent. not only over the unmanured but over plots receiving adequate applications of such manures as nitrate of soda and oilcake, over a period of three seasons including the year of application. The effect on Java indigo in the third year is especially marked.

Phosphate requirements of soil bacteria. Further work on this subject led to the following general conclusions :—

(1) Increase in available P_2O_5 greatly increases the general bacterial activity of a soil, and there-

with the formation of CO_2; there is a positive relation between the amounts of CO_2 thus formed and the solubilization of phosphate in the soil, but this varies with the character of the latter.

(2) Addition of soluble phosphate increased the ammonification rate in all the soils examined.

(3) Addition of phosphate in many cases diminished the nitrification rate, apparently owing to the disproportionate increase in non-nitrifying organisms. The final result over long periods of time in most cases showed no increase in the total nitrate formed.

IV. Indigo.

The experimental factory referred to in the previous annual report came into use at the beginning of the current year (July 1917), and although its working was seriously handicapped by the over-maturity of the plant, many valuable and interesting observations were made during the short manufacturing season remaining. It is impossible here to give any detailed account of the results obtained which will form the subject of a full report shortly to be issued as a memoir of the Department; the following general summary will give some idea of the conclusions arrived at and of the lines of further work made necessary by the character of the results obtained.

Inoculation with specific bacterial cultures. In the previous year's report of this Section it was shown that good reasons existed for believing that yield of indigo in the process of manufacture depended in the first place upon the completeness of bacterial hydrolysis of the indican content of the leaf; that this was determined by the presence or absence of sufficient numbers of specific bacteria, and that variations in yield between individual factories probably depended mainly upon the character of the bacterial flora of the steeping vat, this being again determined by that of the water supply. This contention was fully sup-

ported and the whole theory confirmed by the experiments carried out in the Pusa factory in 1917.

The main line of experiment lay in the comparison of results obtained in artificially inoculated steeping vats and in uninoculated control vats, making use of pure cultures of various hydrolyzing bacteria isolated from the *khazana*, or *seet* water, or from the walls or timbers of the steeping vats of various indigo factories. Isolation of such bacteria was effected by the use of indican agar, on which those bacterial species capable of splitting off indoxyl from indican formed indigo blue colonies, and examination of a large number of samples from various factories has led to the general conclusion that the known yield of a factory is closely and almost directly proportional to the content of such hydrolyzing bacteria in its water supply.

The first problem to attack was the method of inoculating the water used for steeping in such a way as to ensure the presence of sufficient numbers of the specific bacteria. It may be said at once that this problem rapidly revealed itself as the basic one of the enquiry as a whole, and its solution is still under investigation. Nevertheless the results of the comparatively limited number of experiments made in the Pusa factory conclusively established the main principle that yield of indigo depended upon bacterial action, and consequently upon the presence of adequate numbers of bacteria of the proper kind. The very first experiment in which a comparison was made between the yields of two vats, one inoculated with a pure culture of a bacterium (laboratory mark In_{10}) and the other untreated, gave an increase of 15 per cent. in the inoculated vat, notwithstanding the unsuitability of the over-mature plant available which should have been cut for manufacture at least a month earlier. Subsequent experiments were not invariably conclusive so far as yield of indigo was concerned, but owing to the careful analytical watch, both chemical and bacteriological, kept over every stage of the process, it was not only possible to account for discrepancies but to come to definite conclusions as to the underlying

causes of negative results and the feasibility or otherwise of removing them. The general procedure adopted in carrying out each experiment involved chemical examination of the plant before and after steeping, of the liquor at various stages of fermentation and also after blowing and settling, and of the indigo precipitate or *mal* and lastly of the waste or *seet* water. Thus a close watch was kept upon the fate of the original indican content of the leaf, and the effect of any method of treatment upon the percentages of this constituent which appeared at various stages either in its original form or as indoxyl or indigotin, was accurately ascertained. This naturally involved a very large number of analyses and as the quantitative estimation of indican, indoxyl, or indigotin is a tedious process and as each analysis was made, during the later period, both by the persulphate and isatin methods, it will be realized that the number of experiments was limited by the possible pace of output of the analytical data.

In the same way bacteriological analysis of the fermentation process was carried out for each stage of manufacture, but this analysis necessarily began with measurements of the rate of bacterial growth (by plating) in the mass cultures used for inoculation some hours before manufacture commenced, in order to discover the best conditions for securing successful inoculation. Plates were made from the mass culture after various periods of time from the original inoculation, from the *khazana* (reservoir) before and after the introduction into it of the mass culture, and at intervals up to the time of "watering" the vats, *i.e.*, running the water from the *khazana* into the steeping vats containing the cut plant. Fermentation continues after watering for varying periods of time up to some 12—15 hours, and plates were made at intervals to determine the rate of multiplication or otherwise of the specific bacteria artificially introduced with the water. The water used at Pusa was drawn directly from the river, and a large number of plates was made to ascertain the bacterial content of this water and the proportion of active hydrolyzers.

This series of plates showed the very great variation in this respect which occurs in river water from day to day according to the incidence of the rainfall; immediately after rain large numbers of bacteria, derived no doubt from surface wash, appear in the river water; after 24 hours or less this extra supply may have completely disappeared but in the meantime the character of the fermentation may be entirely changed owing to the presence of a relatively enormous number of bacteria in the steeping vat. It is a serious defect in the design of the Pusa factory that no provision exists for settling or filtration of the water, so that in a larger number of cases the extreme dirtiness of the water used introduced excessive numbers of bacteria of all sorts, the activities of which so far complicated the results as to make the latter of little more than negative value. Thus it will easily be realized that when endeavouring to compare an artificially inoculated vat with an uninoculated control, the existence in the water of both of a natural bacterial population already up to the limit of its capacity would inevitably reduce the artificially induced difference in bacterial content to a negligible quantity. A natural criticism immediately suggests itself; would it be practicable on a factory scale to remove any such excess of bacteria in order to make room for artificially introduced species? It may be said at once that the importance of this point was realized very early in the course of the experiments, and our aim has been to find some practicable means of overcoming the difficulty.

In order to understand fully the points involved it must be realized that so far as indigo manufacture is concerned we may divide bacteria into three classes:—

(1) active hydrolyzers,
(2) inert so far as indican is concerned, and
(3) active destroyers either of indican or indoxyl or both.

The artificial cultures isolated at Pusa have been selected for their positive and negative virtues, *i.e.*, they are active

indoxyl producers and do not destroy any large quantity of indican without hydrolyzing it to indoxyl. On the other hand a large number of the bacteria found in the dirty river water are active indican consumers and may, even in twelve hours, destroy some 30—40 per cent. of the indican present, thus reducing the yield of indigo to that extent. In addition to this positive action the competition which goes on between bacteria in any culture medium whether natural or artificial, will seriously reduce the hydrolytic action of the beneficial bacteria if the activities of the latter are curtailed by the presence of superior numbers of the inimical species or even of otherwise inert kinds. It was found in 1917 that interference with bacterial control of the fermentation was due sometimes to excessive numbers of destructive bacteria and not infrequently to the presence in the untreated river water of a sufficiently large number of hydrolyzers to reduce the difference between the artificially produced water content of these desirable organisms and the natural one, and with it the yield of indigo, to insignificance. The frequent, but not constant, occurrence of this phenomenon provided an addition to the evidence upon which the theory underlying this work is based, namely, that the notable differences observed between the yields of individual factories can be correlated with the differences in the bacterial content of their water supply.

Thus in the case of low yields we are confronted at the outset with a condition and not a theory, the presence of destructive, and the absence of constructive bacteria, and the alteration of this condition is the object of our present research.

Two methods of attacking this problem appear to present themselves; the first and most obvious being the removal of all deleterious bacteria from the water supply and the second, the use of artificial cultures of such quantity and vigour as to overwhelm the original population of undesirable bacteria.

It is a well-known fact that bacterial numbers in water can be greatly reduced by settling and still more so by pre-

cipitation; mere storage in reservoirs also reduces them in quantity. Most factories use their *khazanas* or reservoirs as settling tanks, drawing off the water from the top by surface drainers; this is intended to remove suspended mud which would contaminate the indigo, but an extension of the method would undoubtedly serve to reduce the bacterial numbers, and in cases where bad fermentation sometimes followed by bad settling in the beating vat is a common experience of the factory, the use of *khazanas* of greater capacity and designed to effect more complete settling of the suspended matter in the water, would almost certainly lead to improved manufacture. Larger reservoirs would also reduce the proportion of water directly pumped without settling from the river or lake, which in many cases appears to be responsible for bad fermentation. It is a frequently observed fact that certain vats habitually give better fermentation than others in the same factory; various explanations have been given of this difference but the following one which does not seem to have been suggested appears to fit in with the conditions in many cases. In many factories the *khazana* is not large enough to supply water to all the vats in use at one time, so that a certain number of the latter are filled with water which has stood for several hours in the *khazana*, the remainder being watered by practically direct pumping from the outside source, whether river, lake, or tank. This would at once tend to create differences in the bacterial content of the steeping vats, which might very well be of a sufficiently high order to produce variations in the fermentation going on in the latter. Such variations would be reduced together with the number of bacteria by the use of *khazanas* of adequate capacity, allowing of settling the whole amount of water used each day. It is suggested that the not infrequent superiority of the yield of small factories and small vats may be traced to the very generally adequate size of their *khazanas*.

Apart from the bacteria present in the water it is to be remembered that the plant itself introduces an enormous

number into the steeping vat. In the 1917 experiments it was frequently found that whereas the uninoculated *khazana* water might contain very few hydrolyzers yet the corresponding fermented liquor contained an abundance of these bacteria; this implied the introduction of the latter by the plant, and it may be asked how manufacture could be benefited by purification of the *khazana* water, if the plant itself brings in so large a number of bacteria. There is reason to think, however, that this difficulty is not so serious a one as at first sight may appear, first because the bacteria generally associated with the plant do not seem to include as a rule any large number of deleterious organisms, and secondly because these bacteria, if they find the water already in possession of others, as would be the case with successfully inoculated *khazana* water, do not have time to exercise much influence upon the character of the fermentation. For this same reason beneficial plant bacteria must frequently be prevented from carrying out normal hydrolysis by the presence of unduly large numbers of detrimental organisms in the *khazana* water. The problem therefore is how far is it practicable to provide fairly clean water for steeping, and how to produce a satisfactory artificial inoculation sufficiently vigorous to overcome the destructive action of detrimental bacteria already present.

A great deal of experimental work was done to determine the best way of making a "mass" culture, *i.e.*, a pure culture of the specific bacterium sufficient in quantity to stand distribution through the 6,000 to 10,000 gallons of water in the steeping vat without undergoing too high dilution. It was found possible to make a simple culture medium of ammonium sulphate, superphosphate, wood ash and sugar, and to activate fermentation by the use of about one gallon of this culture, after 6 hours' incubation, in each 1,000 gallons in the steeping vat. In many cases, however, growth of the artificial inoculum appeared to be interfered with, probably owing to excessive competition with other bacteria and in some instances to failure to make the proper adjustments between the temperature of the mass

culture and that of the steeping water, or even to the presence of unfavourable chemical conditions in the latter, and further work must be done to find out how to secure the most favourable conditions for the multiplication and activity of the artificially introduced bacteria. In other industries depending upon controlled bacterial fermentation the use of sterilized raw material is generally adopted; this would seem to imply that the absence of other bacteria is a condition of success for the employment of pure cultures, but it does not necessarily follow in the case of indigo. Here we have in the ordinary factory working frequent cases of losses of the order of 30—40 per cent. due largely to imperfect hydrolysis, partly as a consequence of the absence of the proper bacteria and partly to the presence of abnormal numbers of destructive species. It appears probable from the past season's experience that by sedimentation and the introduction of sufficient amounts of vigorous cultures of the proper species it should be possible to alter the character of the fermentation in the steeping vat so as to secure more complete hydrolysis, but a considerable amount of work must be done before it is possible to elaborate a routine method suitable for use in a factory without immediate scientific control.

Hot water extraction. In the report for the previous year (1916-17) reference was made to the use of hot water extraction as a means of eliminating undesirable bacteria; a further advantage of such a method would be to secure a higher percentage of extraction of the indican in the plant; the Indigo Research Chemist has shown that imperfect extraction in many cases leads to a loss of 30—40 per cent. in ordinary factory working, and if hot water extraction could be successfully adapted to factory conditions, it should be possible to obtain a liquor not only comparatively free from bacteria (although of course not absolutely sterile) but containing a much higher percentage of the indican present in the plant from which it was derived.

With a view to obtaining information as to the possibilities of this method a hot water extraction vat was added

to the factory equipment at the beginning of the current year; this consisted of a masonry vat sunk in the ground and having sloping ends and a draining platform. The water in the vat is heated with steam and the hot extract can be pumped to the steeping vats for cooling and inoculation. Plant is carried into and out of the vat by a length of large mesh wire fencing net, thus obviating the trouble in handling hot material.

The experiments made with this method do not come within the scope of this year's report, but it may be said here that there appears good reason to suppose from results already obtained, that the method will allow not only of a high percentage of extraction, but of complete bacterial hydrolysis and the production of good quality indigo. It is, of course, quite possible that its use on a factory scale may prove uneconomical in view of the fuel consumption involved, but engineers whose opinion has been taken do not consider that this is likely to be the case.

V. Pebrine.

Further work was done upon this subject with special reference to the mechanism of infection, a paper on which is now in hand. Microtome preparations and dissection gave clear evidence of the rapid rate of development and spread of the parasite in the tissues of the host in this country as compared with that described by Pasteur; thus artificial infection of a larva, by feeding only once with pebrine-infected food just before spinning, resulted in a heavily pebrinized moth, and in earlier stage larvæ similar treatment resulted in the presence of numerous actively dividing forms of the parasite in the epithelial cells of the gut of the host only three days after infection, as compared with a necessary interval of ten or fourteen days in France. Similarly in hereditary infection through the egg the epithelial cells of the gut of the embryo were found to be infected several days before oviposition. It is therefore clear that *Nosema bombycis* in India has attained parasitic

activity of a high order which is liable to make the spread of the disease even more rapid than was the case in Europe in the middle of last century, when the silk industry was very nearly destroyed, and it is all the more necessary to adopt the strictest measures to prevent such an occurrence in this country. It seems probable that the climatic conditions which enhance the activity of the parasite have a compensating action in reducing the length of time during which the spores retain their infective power, and it may be that this factor has been the only one which has so far prevented the disease from wiping out the Indian silk industry altogether. It should be remembered, however, that this factor only affects the spread of the disease by contaminative infection, and does not at all reduce the hereditary transmission, which is certainly of equal importance.

The viability of pebrine spores was further tested and the results of the experiments showed clearly that under moist conditions such spores rapidly lose vitality, whereas in dry air, even at high temperatures, their viability is retained for considerable periods of time.

The reliance which has been placed upon copper sulphate as an antiseptic for rearing houses was shown to be based on theory rather than observation, as 75 per cent. infection was obtained with pebrine spores treated with 1 per cent. copper sulphate solution, whereas 1 per cent. formalin secured complete immunity under similar conditions.

At the request of the Government of Mysore I visited the State in January and inspected typical rearing establishments, both Government and private. Demonstrations were given of the revised method of examination of moths, and a report was subsequently written embodying a series of suggestions as to the best method of securing adequate and reliable supplies of disease-free seed, and of diminishing the amount of contaminative infection during rearing. These suggestions have been adopted by the Sericultural Department of the State.

Amongst other recommendations the following were emphasized :—

Provision of disease-free seed. Revision of technique of microscopic examination of moths. Proper trained supervision of this examination. Adequate provision of nurseries for production and distribution of disease-free seed. Rejuvenation of stock by hill rearing.

Improvements in rearing. Demonstration rearing houses where improved methods can be shown to local rearers.

Such improved methods to include :—

(1) Sanitary measures to avoid spread of infection such as disinfection with formaldehyde and dust prevention by false ceilings and moist floors.

(2) Proper dieting and spacing, and provision of ventilation especially by openings in roofs of rearing houses.

VI. Programme of work for 1918-19.

Major subjects.

1. The decomposition of organic matter in the soil by bacterial action.

2. The reciprocal relationship between bacterial activity in soil and the mineral constituents of the latter with special reference to phosphates, and an enquiry into the possibility of producing soluble or available phosphates in India without the use of sulphuric acid.

Special enquiries.

3. Indigo.

4. Pebrine.

5. The sterilization of water for troops in the field.

Minor subjects.

6. Biological analysis of soils.

7. Bacterial diseases of plants.

VIII. List of Publications.

Hutchinson, C. M. . Report on Agricultural Bacteriology, 1916-17, for the Board of Scientific Advice in India.

REPORT OF THE IMPERIAL COTTON SPECIALIST.

(G. A. Gammie, F.L.S.)

I. Charge.

I held charge of the post throughout the year.

II. Cottons in the Provinces.

Bombay Presidency.

Khandesh. The whole energies of the local Department have been devoted to the growth and distribution of the **N. R. cotton** (Khandesh *neglectum roseum*, almost identical with the *roseum* of the Central Provinces). There is a large seed farm at Jalgaon, and it is supplemented by areas under registered seed-growers. During these last two years, however, it has been found that *roseum* suffers more from untimely late rains than the ordinary Khandesh mixture, and many cultivators are voluntarily reverting to the former practice of growing the old mixture. In cotton, as in other crops, there are sound reasons underlying the cultivator's method of mixed cropping. While much progress has been made in the distribution of purified N. R. cotton, which is the most profitable type of cotton to the cultivator in the Khandesh mixture, it was felt that some account should be taken of its comparative failure in the last two abnormal seasons and more attention should be paid to the production of a yellow-flowered variety which could take its place, an alternative to be preferred to that of the cultivators returning to their old mixture derived from fresh and uncertain sources. To this end we have introduced, for experimental purposes, the **Sindewahi Cross** from the Central Provinces and **K.22** cotton produced by Mr. Leake at Cawnpore.

The comparative values of the varieties now under experiment can best be calculated from the following statement, based on figures obtained at the Jalgaon farm :—

Variety	Yield per acre	Ginning percentage	Value per acre
	lb.		Rs. A. P.
N. R.	108·30	38·475	28 9 0
N. R. C.	83·80	41·875	23 12 0
Sindewahi Cross	55·23	35·600	15 11 0
K. 22	41·80	36·000	11 1 0

On account of the partial failure of the cotton crop throughout Khandesh, there is a shortage of good seed for sowing purposes, and it is understood that large quantities of seed have been brought from Jamner, a place bordering on the Nizam's Dominions, which grows the ordinary *jari* mixture giving a ginning percentage of 34 to 36 and fetching a slightly higher price than the ordinary Khandesh cotton. Efforts should be made to prevent such inferior types from establishing themselves in tracts which can carry better varieties.

There is a village, called Saising, in the Bhusaval Taluka, which grows a cotton exactly like N. R. excepting that the cotton is not released when the boll opens, even when unpicked for some time. This variety is worth further enquiry on the part of the Department.

Gujarat. In the Dhollera tract Mr. Mankad investigated the extent and limits of the white-flowered form of *mathio* which resembles N. R. in its high ginning percentage. In some villages in the Dhandhuka Taluka of the Ahmedabad District the percentage of white-flowered plants was found larger (varying from 40 to 65 per cent.) than in the tracts of Kathiawar growing *mathio*, where the percentage of white-flowered plants rarely exceeds 25 per cent. The larger percentage of white-flowered plants

in this tract appears to be due to two causes :—(1) N. R. and N. R. C. types ripen a little earlier than the other types of the *mathio* mixture, the fully ripe bolls also appear more fluffy and larger in size. It is therefore probable that the first opened bolls may have been selected by the cultivators for their future seed requirements. (2) Middlemen, who actually sell the *kapas* after testing the out-turn of lint, may have sorted coarse cotton (N. R. and N R. C. having a high ginning out-turn) from the general heaps in the ginneries. As in other parts, *e.g.*, Kathiawar, there is a general complaint that *mathio* exhausts the soil and the succeeding crop of *jowar* (*A. Sorghum*) or *bajri* (*Pennisetum typhoideum*) with which cotton is rotated, has considerably fallen off in out-turn. Cultivators of late have gradually taken to the growing of *wagad*, but it will be difficult to oust *mathio* altogether.

In the Dhollera tract, *rozi* is being rapidly replaced by *ghogari.*

In the Ahmedabad District, *wagad* is restricted to *besur* and black soils, while *lalio* is reserved for *goradu* or the lighter class of soils; on these, when irrigated, its out-turn is sometimes almost doubled. In *wagad* it is better to select round rather than pointed bolls for quality and out-turn.

In the Panch Mahals the prevailing type was *kanvi*, but this has been replaced by *ghogari* on account of its high ginning percentage. At Dohad farm a number of varieties have been tried, amongst them Cambodia and *bhuri*. These have been rejected and tests are being continued with N. R. strains, Sindewahi Cross, and K.22. Owing to the retentive nature of the soil and the chance of frost which occurs at intervals of years these are not altogether satisfactory. Cotton as a crop is not extending on this area as the people get a good return from the double-cropping of maize and *san* (*Crotalaria juncea*).

It would be well if the Department refrained from further experiments towards the introduction of N. R.

which will only accentuate the difficulties regarding mixture in Gujarat, and watched the results with *ghogari* and *kanvi* conducted in the Broach District.

Judged by the valuations, the cottons tried at Dohad stand as follows :—

(1) N. R. ordinary. Rs. 710 per *candy* (784 lb.), spinning 8's; the same day's value of *bengals*, Rs. 730.

(2) N. R. black-seeded. The same as No. 1.

(3) K.22 from Cawnpore. Rs. 800 per *candy*, spinning 14's.

(4) Sindewahi Cross. Rs. 825, spinning 16's; the same day's value of *khandesh* and *akola* being Rs. 760 and Rs. 800.

Comparative tests have been carried out between **Broach Deshi** and *ghogari* at the Broach Experiment Station. Much work remains to be done on the former to bring it even on a par with *ghogari*. The following statement demonstrates conclusively the formidable competition between *broach* and *ghogari* and the Department will have to strain every nerve to prevent the latter from ousting *broach* altogether.

Statement of the results of alternate trials of Ghogari types versus *Broach Deshi.*

Variety of cotton	Yield of seed cotton per acre	Ginning percentage	No. of seeds per tola	Yield of lint per acre	Yield of seed per acre	Gross money value per acre		Total gross income per acre.
						Lint according to valuation	Seed	
	lb. oz.			lb. oz.	lb.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Broach Deshi .	175 14	32·3	231	56 5	119·37	68 7 4	5 3 6	73 10 10
Ghogari A type .	167 7	43·1	235	72 2	95·23	75 15 7	4 2 10	80 2 5
Ghogari B'3 type .	156 10	43·8	241	70 5	83·12	75 1 4	3 12 3	78 13 7
Ghogari E 15 type.	164 7	46·8	238	77 0	87·43	81 0 5	3 13 4	84 13 9

In the Dhollera tract samples of the principal types were taken from general crops and valued in order to

adjudge their respective merits. With *dhollera* of the day standing at Rs. 900, cotton from irrigated *lalio* was valued at Rs. 815, spinning 14's to 16's; that from purified *lalio* at Rs. 880, spinning 20's; and from pure *wagad* Rs. 850, spinning 16's.

In the Junagadh State, two years ago, selections were made in *mathio*. These were put out last year, but owing to the unfavourable character of the season it is premature to say anything on the relative merits of the different types. The Sindewahi Cross is also being tested there.

At Ajupura, in the Thasra Taluka of the Kaira District, where cotton is being grown on newly broken up grass lands, experiments were made with four different sorts of cotton to test the most suitable type for this part which is a new extension of the tract.

The prospects of the successful introduction of a high class selection of **Surat cotton** into this part are very favourable, but the data are not yet sufficient to indicate the most suitable.

At Surat, while the ordinary local cotton gave a profit of Rs. 167 per acre, Selection II gave Rs. 214, Selection I-A, Rs. 200, and Selection 1027 A. L. F., Rs. 184. The last named was considered in the Bombay market to be superior even to *navsari* and was valued at a premium of Rs. 35 per *candy*. There is no doubt that these strains are all superior to the local product and when the difficulties incidental to the distribution of seed of improved cottons on a large scale are overcome the Surat-Broach tract bids fair to supply a very high class cotton.

Southern Mahratta Country. Sholapur and the northern part of the Bijapur District, by growing *neglectums*, have become merged into the Khandesh tract for commercial purposes, and the testing of **Kumpta-Dharwar** varieties is confined to Satara, Belgaum and Dharwar districts and the lower part of Bijapur.

The experiments with *kumpta*, which are confined to the Dharwar farm, gave the following results:—With

kumpta ordinary crop, taken for comparison, and yielding a profit of Rs. 106 per acre, *kumpta* selected for tall compact growth gave Rs. 149, *kumpta* bushy type, Rs. 134, and two *kumpta* crosses, Rs. 149 and Rs. 141 respectively. A *kumpta* crossed with *broach* type gave Rs. 161, and a selection of *broach* gave Rs. 121. The *kumpta* selected is being grown on a field scale for distribution to the cultivators amongst whom it is becoming increasingly popular.

At the Gadag farm, which is the centre for trials with the American types, all evidence points to the superiority of the **Upland** over the **New Orleans** variety, the selection of the former giving a profit of Rs. 218 per acre and of the latter Rs. 149 against Rs. 164 for ordinary **Dharwar-American** per acre. As the value of the Upland type becomes more clearly realized it is expected that the mixture of New Orleans will gradually disappear from cultivation. The **Cambodia** selection was valued on a par with ordinary Dharwar-American giving a profit per acre of Rs. 160. It is difficult to maintain Cambodia in a pure state as it cannot be readily distinguished from Upland Dharwar-American.

In the auction sales, which were conducted by the Co-operative Sale Societies, assisted by the local members of the Bombay Agricultural Department, the crops of Dharwar-Broach and Cambodia were disposed of. Each was arranged in grades based on the ginning percentage, and from the remarks of Messrs. Tata & Sons it was found that this arrangement was also accompanied by definite grades of quality.

The Central Provinces and Berar.

At the Akola farm, the last two seasons have been unfavourable for the cotton crop and under these conditions *buri* has yielded a good profit, Rs. 118 per acre, Berar *jari*, Rs. 71, and *roseum*, Rs. 67-12. The first was originally introduced from Chota Nagpur where the rainfall is copious, the second enjoyed the advantage of being a mixed

crop of which some of the members withstand a wet season, and the third is doubtfully resistant to adverse conditions.

Burma.

The varieties of cotton grown in Burma are the following :—

(1) Wagale (*Gossypium neglectum* v. *Burmanicum*) with yellow flowers.

(2) Wapyu (*Gossypium neglectum* v. *avense*) with white flowers, said to produce a longer boll and whiter lint.

(3) Wani (*Gossypium neglectum* v. *kokatia*), yellow-flowered, but the cotton is khaki which is chiefly used in the making of jackets.

Scattered plants of this type may be found in the local early cotton crop and the pickings contain a slight admixture of this drab cotton, which is usually partially sorted out before the stuff is ginned.

The naked eye is unable to detect any difference in the shape and size of the plant of these three forms until the (2) and (3) come to flower and to pickings.

(4) Wagyi (*G. obtusifolium* v. *Nanking*). This is grown in Prome and Thayetmyo districts and occupies the ground for full nine months. The quality of cotton is superior to the local early type *wagale*.

(5) Pasi cotton (local Kachin name) (*Gossypium neglectum* v. *cernuum*), yellow-flowered. This is similar to the small bolled form found in Khasi and Jaintia hills of Assam, and as it is grown in the same way, in all probability the seed must have been brought from these hills. This is sparingly grown by the Kachins in hills of the Namyin Valley of the Myitkyina District. A thin jungle is cleared and seeds broadcasted along with paddy and vegetable seeds. All these crops come to maturity in succession, cotton being last so that the pickings are not interfered with. The land is abandoned after taking the first year's produce.

(6) Shan State cotton. The plants are reported to be identical with those of the local cotton *wagale*, but the quality of cotton is far superior to any of the races found in Burma. The quality of cotton is almost on a par with *fine surat* and can spin up to 30's. The ginning percentage, however, is said to be only 28 which is far too low to attract attention, but the percentage of cotton to seed of a sample brought from Aungban (Southern Shan State) and tested in the office laboratory was found to be 33·5.

(7) Pernambuco cotton (*G. brasiliense*), kidney or chain seeded. This is not found on a field scale anywhere except that it exists as an ornamental plant in gardens here and there. It is said that a few years ago trials were made with this variety near Moulmein but the cultivation had to be abandoned on account of its failure on a field scale.

Of these varieties the first, *wagale*, is the most important, forming the bulk of Burmese cotton. The quality of cotton as determined by Messrs. Tata & Sons is midway between *bengal* and *khandesh.*

Wagyi is no doubt superior in point of quality, but the longer period required by it will not suit a Burmese cultivator whose land must be got ready in the hot weather.

Experiments with Egyptian and Upland Georgian were conducted for two or three seasons on the Mandalay and Bugi Stations, but though the germination was good the crop was a failure and the trials had to be abandoned.

Some authorities maintain that the Burma cotton crop contains a proportion of fairly long-stapled cotton which if carefully picked and grown separately would be as valuable as the best Indian cottons and command an equally good price.

With this end in view the study of cotton has been taken up seriously by the Department. The Tatkon farm in the Yamethin District and Padu in Saigaing District are both devoting attention to this crop.

Of the type *wagale* a large number of single plant selections were made and isolated in 1914 and their ginning

percentage determined; variation was observed and the best were kept and grown in 1915 and since then the pure strains are grown.

Wagale on the Tatkon farm now gives a ginning percentage of 36 and *avense* up to 42.

In the case of *wagyi*, from a single plant selection a strain has been isolated which gives 45 or about 6 per cent. higher ginning percentage than the unselected crop. Mr. McKerrel thinks that these cultures will maintain their superiority and thus seed will be available for distribution purposes in the near future.

Cambodia on the Tatkon farm and Utopia (New Orleans type) on the Padu farm did not show promise. The former is considerably subject to insect pests and red leaf blight and the latter appeared to be a very poor yielder, bolls do not open properly and it is particularly attacked by insects.

Some crosses with *wagyi* and *broach* have been made to replace *wagyi* which ripens late, but it is doubtful whether these crosses will remain fertile.

On the Tatkon farm, a very promising cross between Shan State cotton and *wagale*, var. *avense*, is made; this strain has a ginning out-turn of 40 per cent. as compared with 33 in ordinary *wagale*. The testing of this strain on a field scale will in a short time throw sufficient light on the cotton question in Burma.

It is certain that a great advance can be effected by selection of the local types alone.

In order to increase the area under cotton it is essential that the grower be given a reasonable price for the produce, ginneries be opened in suitable tracts to induce keen competition among buyers. and that the cultivator should use the drill in sowing, thus saving a lot of seed and rendering after cultivation easier whereby the crop will grow even and should give a better out-turn.

Acknowledgments. Thanks are due to Messrs. Tata & Sons for their generous help in passing judgment on all the samples submitted to them.

III. Programme of work for the year 1918-19.

Major.

(1) To visit and advise on points regarding cotton and its cultivation whenever required to do so by the Provincial Departments of Agriculture.

Minor.

(2) The study of the behaviour of *bhuri*, Cambodia and other such cottons in non-cotton-producing tracts, as detailed in the last year's programme, will be continued.

(3) An enquiry into the manurial requirements of cotton will be made.

(4) Researches on the botany of cotton will be continued.

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REPORT OF THE DIRECTOR.

(G. A. D. STUART, I.C.S., AND E. J. BUTLER, M.B., F.L.S.)

I. CHARGE AND STAFF.

Charge. Mr. J. Mackenna, C.I.E., I.C.S., held charge of the office of the Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, up to the 2nd October, 1918, and again from the 4th November, 1918, to the 12th April, 1919, when he proceeded on 6 months' privilege leave. Dr. W. H. Harrison acted as Agricultural Adviser and Director from the 3rd October to the 3rd November, 1918, and Mr. G. A. D. Stuart, I.C.S., assumed charge from the 13th April, 1919.

Dr. E. J. Butler, M.B., F.L.S., has been appointed Joint Director of the Institute, in addition to his duties as Imperial Mycologist, from the 20th January, 1919, and the appointment of the Assistant to the Agricultural Adviser to the Government of India held by Mr. Wynne Sayer, B.A., has been temporarily placed in abeyance from the same date.

Staff. Dr. E. J. Butler, M.B., F.L.S., Imperial Mycologist, was on deputation to the Federated Malay States, to report on the Agricultural Department there, from the

8th July to the 13th November, 1918. During his absence, Dr. F. J. F. Shaw, A.R.C.S., F.L.S., officiated as Imperial Mycologist, and Mr. J. F. Dastur, M.Sc., then First Assistant of the Mycological Section, acted as Second Imperial Mycologist. Mr. Dastur has since been appointed to the Indian Agricultural Service as Supernumerary Mycologist and deputed to England for fifteen months for training.

Mr. G. S. Henderson, N.D.A., N.D.D., was confirmed in the appointment of Imperial Agriculturist from the 1st March, 1918. On the termination of his temporary duties as Controller (Agricultural Requirements, Mesopotamia) under the Indian Munitions Board on the 22nd June, 1919, he proceeded on six months' combined leave. Mr. Wynne Sayer officiates as Imperial Agriculturist from the 20th January, 1919.

Mr. F. M. Howlett, B.A., F.E.S., Imperial Pathological Entomologist, was deputed for a period of 6 months from the 24th January, 1919, under the Indian Research Fund Association to conduct experiments with mosquito repellents.

Mr. J. H. Walton, B.A., B.Sc., on the termination of his duties under the Military Department, reverted to his appointment of Supernumerary Agricultural Bacteriologist on the 10th April, 1919. During Mr. Walton's absence of nearly four years he saw active service with the armies in Mesopotamia, Egypt and Palestine.

Captain W. Hodgkinson, R.E., worked in the laboratory of the Imperial Agricultural Bacteriologist throughout the year, in collaboration with that officer in electrical methods of water sterilization.

Mr. J. Sen, M.A., F.C.S., Supernumerary Agricultural Chemist, continued throughout the year on deputation under the United Provinces Government.

Mr. M. Afzal Hussain, B.A., M.Sc., who has been appointed to the Indian Agricultural Service, was posted to Pusa as Supernumerary Entomologist from the 6th January, 1919.

II. Work of the Institute.

Scientific work. The scientific work of the Institute during the year is described in the reports of the various sectional heads. The more important investigations were the following :—

On the Pusa farm, which is managed by the Imperial Agriculturist, besides carrying out manurial, rotational and varietal tests, the economics of steam cultivation are being studied. In view of the favourable reports of motor cultivation from home, a Fordson motor tractor was obtained during the year. A demonstration of its working was given in the presence of a large number of people from all parts of India. The tractor worked with implements in use on the farm and did all that it was asked to do in excellent style. Experiments are in progress to determine working costs, etc. The work on the breeding of pedigree herds of cattle is increasing in importance. Besides the pure Montgomery and half-bred Ayrshire × Montgomery herds, there are now three-quarter-bred, double cross-bred and quarter-bred calves on the farm. Careful observations and records are being kept with a view to collecting data as to hardiness, milk yield, etc., of the various crosses. A series of calf-rearing and feeding experiments are also in progress. During November, 1918, 169 cattle were inoculated against rinderpest by the serum simultaneous method, without any casualties. The demand for the surplus stock disposed of at the half-yearly sales was very brisk and high prices were realized.

In the Chemical Section, further investigation was made as to the value of Dyer's method in estimating available phosphoric acid when applied to calcareous soils. Attention was also directed to the retention of phosphoric acid in calcareous and non-calcareous soils. The influence of windrowing on the sugar content of sugarcane in the Peshawar valley and the direct and indirect action of green manures in relation to paddy cultivation were other important investigations in progress in this Section.

Besides creating new centres of distribution of Pusa 12 and 4 which are now preferred to the country wheats wherever they have been introduced, the Botanical Section reached during the year an important stage in the breeding of rust-resistant wheats. Many new forms which are characterized by strong straw, rust-resistance, good standing power and heavy yields have been fixed, and these are being tested on a field scale. The Howards' experiments in water saving in wheat growing have shown that if the texture of the soil has been improved and if the surface has been properly graded, extremely heavy crops are possible with a comparatively small volume of irrigation water. The agricultural side of the indigo problem continued to be studied in this Section. The effect of drainage on crop production and the pollination of Indian crops were some of the other lines of work on which Mr. and Mrs. Howard were engaged during the year.

The Ufra disease of rice, the black band disease of jute, sugarcane smut, the pigeon pea wilt and the diseases of chilli principally engaged the attention of the Mycological Section during the year under report. The various diseases affecting fruit trees are also under study in the orchards in the Kumaon hills, and spraying experiments are being carried out both there and in Peshawar.

In the Entomological Section, besides working in determining the relative immunity of certain varieties of cotton from bollworm attack and studying the borer pests of sugarcane and other graminaceous plants, special attention was paid during the year to the collection of information regarding fruit-pests. It has been ascertained that the "Tukra" disease of mulberry is caused by a mealy-bug, and that the affected apical leaves if fed to mulberry silkworms assist in inducing flacherie. The enquiry regarding the occurrence in the Indian Empire of any insects which may be used as efficient checks on the growth of *Lantana* was completed during the year and the results are being published separately. The work in connection with bees, lac and silkworms was continued.

Practically throughout the year, Mr. Howlett, Imperial Pathological Entomologist, was on special duty in connection, firstly, with the prevention of surra-transmission by Tabanidæ, more particularly among transport camels, and, secondly, with the improvement of existing culicifuges for military use. Reports on the work in these two directions have been submitted to Government.

Problems of soil biology under investigation in the Bacteriological Section during the year under review were:—(1) Seasonal variations in nitrification in soils under crop and fallow; (2) different rates of nitrification of various organic materials in soil; (3) inhibition of nitrification by toxins resulting from anaerobic incubation of soils; (4) green-manuring; and (5) fixation of nitrogen by legumes. Among enquiries of industrial value, Mr. Hutchinson, besides continuing his work on indigo and the pebrin disease of silkworms, succeeded during the year, in collaboration with Captain Hodgkinson, in producing a solution containing 3-4 per cent. available chlorine by electrolysis from purely Indian raw materials, for the sterilization of water. The solution can be prepared anywhere where electric current is available without expert knowledge either of chemical or electrical methods.

The work done by the Indigo Section is published in a special series of Indigo Publications started by the Institute. A separate annual report has therefore not been considered necessary.

Training. A number of post-graduate students attended the Institute during the year and short courses were given in sericulture and lac-culture:—

	Number of students
General Agriculture	2
Agricultural Chemistry	1
Mycology	2
Economic Entomology	2
Agricultural Bacteriology (including bacteriological technique in silkworm disease)	2
Sericulture	4
Lac-culture	2
TOTAL	15

Besides the regular students, Mr. S. N. Bal, Assistant Professor of Botany, Science College, Calcutta University, spent about a fortnight in the Mycological Laboratory in March and April as he proposes to take up mycological work in Calcutta.

III. Publications.

Six Memoirs, 13 Bulletins (including three reprints and one vernacular version), and three Indigo Publications were issued during the year, while ten publications were in the press at the close of the year.

The demand for the Bulletin on "Insecticides, Mixtures and Recipes for use against Insects in the Field, the Orchard, the Garden and the House" continued, with the result that it had to be printed a third time during the year. A Bengali version of Bulletin No. 46 on Bee-keeping, written in language simple enough to be understood by the village folk when read by themselves or read out to them, was issued during the year and the whole edition rapidly sold out.

The Agricultural Journal of India in its new form continues to gain in popularity, and it became necessary during the year to increase the print order by 250 copies. It is proposed to issue the Journal bi-monthly, instead of quarterly, with the commencement of the New Year. All the present features will be maintained, but no increase will be made in the annual subscription.

IV. General Administration.

Buildings and works. The bungalow for the Electrical Engineer referred to in last year's report was completed during the year. The construction of quarters for the First Assistant to the Imperial Mycologist as well as for the staff of the Pusa High English School will be begun as soon as the necessary materials are available. Necessary funds have also been allotted for the construction of a building for the Post Office and a rest house for Indian visitors. A pumping set has been installed on the river

Gandak to tide over the period until a more satisfactory scheme of irrigation can be worked out.

Library. In addition to the 1,656 bulletins, memoirs, reports, books and reprints received in exchange, 457 new volumes were purchased during the year. A fourth edition of the catalogue of the library is in the press.

Pusa School. The total number of pupils attending the Pusa High English School on the 30th June, 1919, was 192 as against 160 on the corresponding date of last year. Of the 11 students sent up for the Matriculation Examination of the Patna University, seven were successful.

General health of the station. Although the neighbouring villages suffered severely with the rest of India from the influenza epidemic, it was noteworthy that the number of cases on the Pusa estate were relatively few and there was not a single death. This was not a little due to the precautionary measures taken by the Medical Officer, Mr. S. Gupta, and his staff, who deserve great credit. Medical relief was afforded to 19,938 out-patients and 203 in-patients in the hospital and dispensary attached to the Institute during the year under report.

V. Accounts.

The total expenditure during the financial year 1918-19 was Rs. 6,06,640, as against Rs. 5,81,723 during the previous year. The details are given below :—

	Rs.
Office of the Agricultural Adviser and Director	2,35,301
Chemical Section	38,129
Mycological Section	42,954
Entomological Section	55,073
Pathological Entomological Section	38,131
Bacteriological Section	32,860
Botanical Section	50,327
Agricultural Section	63,594
Indigo Research Section	50,271
Total	6,06,640

A sum of Rs. 15,000 was paid as a grant-in-aid to the Indian Tea Association.

The principal items of expenditure under the annual grant of Rs. 10,000 placed at the disposal of the Agricultural Adviser to the Government of India for special agricultural experiments were as follows:—

	Rs.
Purchase of a corn crusher	655
Purchase of a chaff cutter	596
Purchase of canvas paulins for the Pusa Farm .	652
Paid to the Director of Agriculture, Bengal, for the cost of a mechanical fibre extractor . . .	1,457
Experimental cotton cultivation by the Imperial Cotton Specialist	1,200
Pay of a Veterinary Assistant in connection with cattle breeding and that of a Fieldman for mosquito experiments	1,431

The gross receipts during the year from the sale of farm produce, milk, publications of the department and other articles amounted to Rs. 21,403 as against Rs. 19,843 in the previous year.

VI. Conferences.

The Government of India having accepted the recommendation of the tenth meeting of the Board of Agriculture in India held at Poona in 1917 that sectional meetings of mycologists, entomologists and chemists be held in years in which there is no meeting of the Board of Agriculture, such meetings were held at Pusa in February, 1919. In accordance with the recommendation of the Board, they were not confined to members of the Agricultural Department. The Indian Tea Association and Portuguese India were represented at both the Mycological and Entomological Meetings, whilst the Forest Zoologist attended the Entomological Meeting. The latter meeting also attracted visitors from outside India, the Egyptian Government sending an official delegate in Dr. Lewis H. Gough, Director of the Entomological Service in Egypt, and Mr. R. Senior-White attending from Ceylon. Detailed proceedings of these meetings are being issued.

A cattle conference was also held at Pusa during the year, when several problems connected with the Pusa dairy herd were discussed.

VII. Visitors.

The most notable visitor during the year was His Excellency the Viceroy. This was the first time that the Institute was honoured by a visit from a Viceroy. Lord Curzon had previously visited Pusa, but he came only to lay the corner stone of the splendid building which houses the various laboratories of the Institute. His Excellency Lord Chelmsford, who was accompanied by the Hon'ble Sir Claude Hill, Member in charge of the Revenue and Agriculture Department, spent three busy days (4th to 6th January) in going over the various Sections and evinced much interest in all that he saw.

In all about 165 ladies and gentlemen visited the Institute during the year. These included:—

Lieutenant-Colonel F. H. G. Hutchinson, M.B., I.M.S., Sanitary Commissioner with the Government of India; Dr. C. A. Bentley, M.B., D.P.H., D.T.M. & S., Sanitary Commissioner to the Government of Bengal, Mr. P. J. Hartog, C.I.E., M.A , B.Sc., L-es-Sc., Academic Registrar of the University of London and Member of the Calcutta University Commission; Professor C. V. Raman, M.A., Palit Professor of Physics, Calcutta University; Mr. A. B. Shakespear, C.I.E., of Messrs. Begg Sutherland & Co., Cawnpore; Mr. G. E. C. Wakefield, O.B.E., Director General of Industries, Agriculture and Commerce, Hyderabad (Deccan); Lieutenant-Colonel Milton, Assistant Director of Grass Farms, Meerut; Lieutenant-Colonel J. Matson, Assistant Director of Military Farms, Northern Circle, Ambala; Major V. B. Nesfield, F.R.C.S., I.M.S.; Captain Froilano de Mello, Director of the Bacteriological Laboratory, Goa, Dr. L. H. Gough, Director of the Entomological Service, Egypt; Mr. S. Higginbottom, Director of Agriculture, Gwalior; Mr. C. F. C. Beeson, M.A., Forest Zoologist, Forest Research Institute, Dehra Dun; Mr. J. C. Nag, Senior Professor of

Botany, Presidency College, Calcutta; Mr. E. A. d'Abreu, F.Z.S., Curator of the Central Museum, Nagpur; Mr. C. C. Monckton, of Nairobi; Mr. R. Senior-White, F.E.S., Matale, Ceylon; Kumar Chandreswar Prasad Narayan Singh of Sursand and Syed Shafael Hussain of Gaya.

Among other visitors were officers of the various Provincial Departments of Agriculture, and planters and zamindars of estates surrounding Pusa. A party of students from the Sabour Agricultural College, under two Assistant Professors, also visited the Institute during the year.

REPORT OF THE IMPERIAL AGRICULTURIST.

(Wynne Sayer, B.A.)

I. Charge and Training.

I was in charge of the Farm, in addition to my duties as Assistant to the Agricultural Adviser, up to the 20th January, 1919. From that date I have been officiating as Imperial Agriculturist.

Training. Mr. Kalyan Mal Banthia was under training in agriculture and cattle work during the year.

B. Dalip Singh, an Overseer from the Karnal Military Dairy Farm, was admitted to a course of six months' practical agriculture on the farm from 30th May, 1919.

Conference. A Cattle Conference was held at Pusa on 17th and 18th February, 1919, when several matters connected with the Pusa herd were discussed.

II. Pusa Farm.

The Season. The year 1918-19 was remarkable for early rain in May followed by a heavy rainfall for the year, 60·19 inches being registered as against 45·54 inches for last year. But the distribution was so uneven that it was by no means a good year. The failure of the *hathia* in October told heavily upon the *rabi** crop which was only saved from disaster by a short rain in January, too late, however, to affect the main crop to an appreciable extent. Floods started on the 1st June which is unusually early, and heavy rain on the 25th and 26th of August accompanied by strong winds laid most of the maize, and, in short, the record of the whole season goes to prove that it is the distribution far more than the actual quantity of rain that counts from an agricultural point of view.

* Crop sown in winter.

I give below the rotation under which the farm is worked, and a reference to the plan of the arable area printed opposite will assist the reader.

	1st year	2nd year	3rd year
Kharif*	Maize for silage and fodder	Maize for corn	Pulse green crop
Rabi	Oats .	Rahar (*Cajanus indicus*)	Oats

* Crop sown in monsoon.

The object of this rotation is to work the land to the best advantage and provide grain and fodder for the herds.

The cattle are soiled on the third year pulse crop and this practice is showing good results on the higher lands.

The cropping of the various fields on the farm is shown on the plan and is here dealt with in detail.

By arrangement with the Controller of Agricultural Requirements for Mesopotamia, Poona, an extra area was put down under oats in order to provide seed for Mesopotamia.

1st year rotation. A dressing of 10 tons farmyard manure or 10 maunds cake is given and the land is put under maize or *juar* (*A. Sorghum*) for silage or fodder followed by oats in the *rabi*.

Four fields aggregating 132 acres were sown with maize and *juar*. The best yield was from Chanman where 17 acres gave 344 maunds per acre, and the average yield throughout was 200 maunds per acre. The same fields under oats in *rabi*, with the exception of 16 acres left fallow for levelling, gave an average yield of 14 maunds per acre, the best yield being 16 maunds per acre from Brickfield No. 1.

The working costs for the year for both crops came to Rs. 43 per acre and the return Rs. 130, giving a working profit of Rs. 87† per acre for the year.

† This does not include rents, rates and taxes or charges for supervision.

PLAN OF PUSA FARM
(ARABLE AREA)
SCALE 4" = 1 MILE

2nd year rotation. No manure is given here. Maize and *rahar* are sown together and the *rahar* stands for the *rabi*, thereby saving us a considerable amount of cultivation at the busiest time of the year. One hundred and thirty-three acres were sown, 93 standing under maize and *rahar* and 40 under jute which is grown for the Fibre Expert and is taken in the second year rotation. Cultivation costs were Rs. 23 per acre for the year, and the return Rs. 100, giving a profit of Rs. 77.

This was a good year for *rahar* and the best field Gohree gave $14\frac{3}{4}$ maunds, and the average over all was nearly 12 maunds. The maize did badly owing to heavy rain at the wrong time, and the best yield was only $10\frac{1}{2}$ maunds per acre from Gohree. As is usually the case with crops sown together, we made on one what was lost on the other, a most important thing considering the large number of cattle dependent on the farm for grain.

3rd year rotation. Here pulse crops are sown in *kharif* for feeding off on the land. One hundred and thirty-four acres were put down under *guar* or cluster beans (*Cyamopsis psoralioides*), soy beans, cow peas, velvet beans and *math* (*Phaseolus aconitifolius*), and the cattle were penned on a small area daily. The early flooding of the *dhab* grazing area brought the cattle on to the soiling crops early in the season and by close hurdling the whole area was thoroughly gone over, 230 head of cattle being put on an average of 1·13 acres daily and the soiling continuing for 78 days. *Guar* is the most satisfactory pulse for soiling. Cattle eat it readily and it is not difficult to bury green, while it smothers the land satisfactorily while standing. The usual troubles of hurdle breaking and hoven were in evidence and the young cross-bred bulls were troublesome when near the cows, but the results on the land and succeeding crops fully justified the close soiling, and it is to be recommended to any one who runs a herd of cattle in connection with an arable farm, the saving in labour of cutting and carting the green crop alone being considerable. A decent hurdle not too heavy

and yet strong enough to stop cattle has yet to be evolved. Ideal fencing was tried and proved useless while bamboos were much too light.

Oats followed the pulse crop over 105 acres, a small area being in wheat. One maund of superphosphate was given at the time of sowing. The best yield was 19 maunds an acre from Phatak and Nepali fields and the average yield was 15 maunds. Wheat averaged 13 maunds per acre on the whole area. Working costs were Rs. 26 per acre and the return Rs. 93.

Sugarcane. The usual area, 8 acres, was put under cane and 16 varieties were planted. The cane is grown without irrigation, 27 maunds of rape-cake being applied per acre, half given at planting and the remainder at first ridging on the break of the monsoon. The cane yield averaged 611½ maunds per acre and was sold green at 8 annas per maund to the factory direct.

The cost of cultivation was Rs. 126 per acre and the return Rs. 305.

Sixteen varieties were grown. Among the thick canes were Sathi, Purple Mauritius and Kaludai Budan; while J. 33, J. 36, Mungo, Yuba and Saretha did well among the thin varieties.

Twenty-three varieties from Dr. Barber, Government Sugarcane Expert, were also grown for comparative tests and those that did well are being tried on a larger scale. All cane planting, except placing the setts and manure in the furrow, is done by bullocks and the saving in labour is considerable, while the return made on this area shows clearly that cane grown in this fashion will do well; the thick varieties in particular averaging out excellently.

Jute is grown on the farm for seed by arrangement with the Fibre Expert and the seed after being treated with copper-sulphate is sent out to Bengal. Till last year the crop was grown on the main area of the farm but as it was impossible to spare this class of land from fodder crops for the cattle it was sown this year in Goojarmalla, a field liable to be flooded, being outside the protective embankment, and

therefore unable as a rule to hold a *kharif* crop. This being the first year jute has been sown there, the season has retaliated by being exceptionally free from floods. It looks however as if the present arrangement will have to terminate as the whole area is required to meet the ever increasing needs of the farm herds.

Experimental work. This work was continued in the two fields, Punjab and North Pangarbi, set apart for the purpose.

(*a*) The permanent manurial and rotational experiments were continued. A proposal for discussion of all results so far obtained and consideration of the question of the continuance of the experiments has been placed on the agenda at the next meeting of the Board of Agriculture when the matter will be thoroughly dealt with.

(*b*) The green-manuring experiments, run in collaboration with the Imperial Agricultural Bacteriologist, were carried a step further in the testing of the residues. The yields from the different plots from the beginning are given below :—

Particulars	Yield of oats (grain) per acre in 1917	Yield of green maize per acre in 1918	Yield of oats (grain) per acre in 1918	Particulars	Yield of oats (grain) per acre in 1917	Yield of green maize per acre in 1918	Yield of oats (grain) per acre in 1918
	After green manure	After oats	After maize		After green manure	After oats	After maize
	lb.	lb.	lb.		lb.	lb.	lb.
3 times san-hemp fermented with 3 cwt. superphosphate per acre.	1,977	21,748	1,131	3 times san-hemp fermented without superphosphate.	1,485	21,091	1,168
6 times san-hemp fermented with 3 cwt. superphosphate per acre.	2,643	29,501	1,564	6 times san-hemp fermented without superphosphate.	1,561	27,793	1,094
San-hemp ploughed in with 3 cwt. superphosphate per acre.	2,080	20,960	764	San-hemp ploughed in without superphosphate.	1,259	20,861	690
Superphosphate alone at 3 cwt. per acre without green manure.	1,185	20,196	554	No superphosphate and no green manure. (There are 3 such plots. Average of these entered.)	1,040	18,395	666

Should the maize yields this season show that the plots are still holding a residue, the entire series will be put under oats in *rabi*.

(*c*) The experiments, in collaboration with the Imperial Mycologist, regarding a method of dealing with "die-back" in chillies were continued.

(*d*) Twenty-three varieties of wheat from selected strains were under trial. The average yield per acre from all varieties was $15\frac{3}{4}$ maunds but a great deal of rust was observed on several varieties, those from Jubbulpore being especially bad.

Late ripening also put several other varieties out of court.

The best yields were as follows :—

	Mds.	Seers
8A Lyallpur	26	...
Sindhi Pissi	22	27
Maroo Booji (Sindhi)	20	28
Lal of Jhelum	19	37
Pusa 12	19	31
Federation	16	37

Federation which was said to be too late in ripening for Bihar, distinguished itself by being ripe at the same time as Pusa 4. It was harvested from 16th to 21st March, while Pusa 4 was harvested between 13th to 20th March. But its yield was disappointing and further tests will be carried out in which the new variety of improved Federation (Hard Federation) which is said to be a distinct improvement on the present wheat will be tried. Much interest was taken in the 2 acres of Federation grown on the farm and seed has been given out to several planters and also to the Director of Agriculture, United Provinces, for trial. The stiffness of its straw is one of its most noticeable points. I have myself seen a big block of this wheat which ultimately gave 40 maunds per acre, standing after heavy wind and rain without a straw down; and as a stiff straw is an essential for a heavy yield, this wheat will

be found capable of giving a big return on lands which will lay other wheats.

(*e*) The experiments for testing yields of green fodder with yields of seeds and comparative economic value of the common leguminous crops were continued. There are two series in this experiment. One series is grown to produce green fodder in *kharif* and is followed by winter pulses for seed in *rabi*. The second series is for seed of both *kharif* and *rabi* pulses.

"A" SERIES.

Kharif pulses	Green fodder per acre in lb.	How dealt with		Rabi pulses	Weight of seed in lb. per acre
		Fed to cattle	Left by cattle		
Florida velvet beans . .	13,670	3/4	1/4	Lentils	1,394
Florida Beggar weed . .	4,846	1/3	2/3	*Dolichos Lablab* . .	926
Cow peas	10,184	6/7	1/3	White peas . . .	536
Soy beans	7,145	4/5	1/5	Purple peas . . .	1,064
Cluster beans . . .	12,106	2/3	1/3	Gram of Gujarat District	1,645
Dolichos Lablab . .	1,643	2/3	1/8	Gram, local . . .	1,848
Urid (*Phaseolus radiatus*) .	11,868	10/11	1/11	Gram, Cabuli small .	1,343
Math	17,905	12/13	1/13	Gram, Cawnpore . .	1,185

"B" SERIES.

Kharif pulses	Weight of seed per acre in lb.	Rabi pulses	Weight of seed per acre in lb.
Florida velvet beans . . .	928	Fallow as velvet beans were harvested late.	..
Florida Beggar weed . . .	47	Purple peas	838
Cow peas	267	Gram Cawnpore	963
Soy beans	1,224	Fallow as soy beans were harvested late.	..
Guar	772	Gram, small Cabuli . . .	805
Val (*Dolichos Lablab*) . . .	528	Val (*Dolichos Lablab*), same crop standing in rabi.	..
Urid	207	Gram, local Orai Farm . . .	382
Math	1,022	Gram of Gujarat District . .	435

In series "A," of the *kharif* pulses the best is *math* both in feeding value and weight of crop. *Urid* is next and then *guar*. Florida velvet beans make a big crop but fall

off in feeding value. Florida Beggar weed is a wash-out at Pusa. Soy beans are moderate while *Dolichos Lablab* does not do. In *rabi* pulses gram comes first followed by lentils and purple peas.

In " B " series, as regards *kharif* pulses the highest yield of seed was got from soy beans, but this crop holds the land in *rabi* also, which puts it out of consideration.

Florida velvet beans and Florida Beggar weed are poor yielders. *Urid* and *Dolichos Lablab* are also poor. The *rabi* pulses were purple peas and gram. They were sown late as the *kharif* crop occupied the ground till late. If sown at the proper time, I think the result would have been equal to those of " A " series.

(*f*) Experiments with Java and Sumatrana indigo were carried on in collaboration with the Indigo Research Chemist and Imperial Agricultural Bacteriologist. As mentioned in last year's report, these will be continued over a period of years and the results will be dealt with from time to time by the Indigo Research Chemist and the Imperial Agricultural Bacteriologist in their respective reports.

As in past years, crops for the various experts were grown in North Pangarbi. Experiments on *rahar* wilt referred to in last year's report were carried out in collaboration with the Imperial Mycologist and the Fibre Expert. They will be continued next year.

Buildings and Machinery. The new silage cutter—Climax—referred to in last year's report, was worked throughout the season and cut 12,000 maunds of silage. It has proved itself a thoroughly reliable, serviceable machine, and, when worked in connection with a tractor, forms one of the handiest silage cutting outfits it is possible to have on a farm.

The 4′ 6″ Marshall's thresher turned out no less than 513 maunds of cleaned oats in a day, thus beating last year's record of 505 maunds. Regular feeding and a total absence of any stops except those for oiling enabled us to work off

4,932 maunds of various grains such as oats, wheat, gram and *rahar* in 36 days and finish by the 23rd April, thereby escaping all damage from the early rain in May, a result which reflects the greatest credit on all concerned and shows what can be done with machinery in India.

Steam Ploughing Tackle. The set of tackle consists of two single cylinder K Class Fowler engines with 900 yards steel wire rope and a four furrow anti-balance gang plough, a disc harrow, a grubber, a zigzag harrow and a Crosskill roller. The cost of purchase in 1913 was as follows:—

	Rs.
Two engines with steel cables	30,000
Plough	3,700
Disc harrow	3,625
Grubber	3,227
Zigzag harrow and roller	2,925
TOTAL .	43,477

The tackle worked in the season 1918-19 for 145·4 days, the working day being reckoned at 10 actual working hours. The tackle stood idle during the remainder of the season.

Details of output, consumption and costs including all expenses except depreciation and interest on outlay are given below.

Statement A.

Output, consumption and cost of steam tackle during 1918-19.

(a) *Output.*

Year	Working days	Summary of work done										Average acres per day			
		Ploughing		Disc harrowing		Grubbing		Rolling		Total		Ploughing	Disc harrowing	Grubbing	Rolling
		Days	Acres	Days	Acres	Days	Acres	Days	Acres	Days	Acres				
1918-19 . .	145·4	50·65	373·5	36·90	605·5	32·20	668·0	25·65	540·0	145·4	2187	7·3	16·4	20·7	21·0

(b) *Consumption.*

Year	Days	Coal and Wood		Engine oil	Cylinder oil	Grease	Waste
		Total	Per day				
		Mds. Srs. Ch.	Mds. Srs. Ch.	Mds. Srs. Ch.	Mds. Srs. Ch.	Mds. Srs. Ch.	Mds. Srs. Ch.
1918-19 . . .	145·4	4,675 10 0	32 6 0	12 4 10	4 8 6	1 0 0	1 35 5
		109 25 0	0 30 0				
		4,784 35 0	32 36 0				

(c) *Cost.*

Year	Days	Analysis of working cost					Working cost per acre			
		Labour*	Coal and wood	Lubricants and wastes	Total	Per day	Ploughing	Disc harrowing	Grubbing	Rolling
		Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
1918-19	145·4	933 10 9	1,655 13 9	481 14 9	3,071 7 3	21 2 0	2 14 4	1 4 7	1 0 4	1 0 1

* Labour constitutes the wages of two drivers, two firemen, two implement men, and water and coal carriers.

Year	Days	Up-keep and duplicates	Inspection fee	Total expenses	Total cost per acre			
					Ploughing	Disc harrowing	Grubbing	Rolling
		Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
1918-19	145·4	789 4 1	275 0 0	4,135 11 4	3 14 4	1 11 9	1 6 0	1 5 8

STATEMENT B.

Showing cost for working and maintaining the tackle in 1916-17, 1917-18 and 1918-19.

Particulars	1916-17 No. of working days 151	1917-18 No. of working days 121	1918-19 No. of working days 145·4
	Cost	Cost	Cost
	Rs. A. P.	Rs. A. P.	Rs. A. P.
Labour	1,233 0 0	940 1 6	933 10 9
Coal	1,788 0 0	1,424 9 0	1,655 13 9
Oil	300 0 0	315 0 0	481 14 9
Miscellaneous stores, etc., and renewals	713 0 0	3,418 13 9	1,064 4 1
TOTAL	4,034 0 0	6,098 8 3	4,135 11 4

Statement C.

Showing the above costs divided into following operations per acre in the year 1916-17, 1917-18 and 1918-19.

Particulars	1916-17			1917-18			1918-19.		
	Total area cultivated in the year	Cost per acre	Best day's work	Total area cultivated in the year	Cost per acre	Best day's work	Total area cultivated in the year	Cost per acre	Average per day
	Acres	Rs. A. P.	Acres	Acres	Rs. A. P.	Acres	Acres	Rs. A. P.	Acres
Ploughing	267	4 6 2	7	170·5	9 3 2	7·	373·5	3 14 4	7·3
Disc harrowing	498	2 0 9	18	821·5	3 0 3	20	605·5	1 11 9	16·4
Grubbing	1,080	1 7 4	25	616·0	4 5 7	26	668·0	1 6 0	20·7
Zigzag harrowing . . .	41	0 14 9	27	11·0	2 2 6	...	...	...	...
Rolling	320	1 5 6	22	173·0	3 14 0	22	540·0	1 5 8	21·0
Total .	2,206		...	1,792		...	2,187		...

It will be seen from the Statements B and C that the cost of operations is now at the 1916-17 level, and that the 1917-18 figures may be taken as abnormal owing to war conditions. The entire tackle is in thorough working order and, with the rigid system of replacements practised, may be calculated to be as good as when first purchased. The work done by it is excellent, but the heavy capital cost still remains a drawback to its general adoption on estates, and it is to be feared that this cost will never revert to pre-war figures.

A Fordson motor tractor (Plate I) was bought in May, and a demonstration of its working was given on the farm. As this was the first tractor of its type to be worked in India, much interest was displayed in the demonstration and a large number of people attended from all parts of India.

The tractor worked with implements in use on the farm and did all that it was asked to do in excellent style. It was hitched successively to a double furrow disc plough, a Ransome's cultivator, Cambridge roll and rake of three spring tooth-harrows, and afterwards was used to run the silage cutter. One could not fail to be struck with its work over ploughed land which was good, thorough, and showed no sign of poaching the land or failing to get a driving grip. Its weight 21 cwt. all on appears to be the optimum for these operations. It is an extraordinarily handy machine and, with its light weight and great power, is well adapted to Bihar conditions. It is now working regularly on the farm and careful records are being kept of its fuel consumption, etc. A report will be issued in due course, and I take the opportunity of stating here that pending the completion of thorough trials and the issue of this report, I am not prepared to express any definite opinion as to its capabilities. Any one wishing to see it working is welcome to do so. It is hoped to be able to run parallel experiments with other types of tractors this winter; and also to test fully the various types of implements provided with these tractors, and there seems little reason to doubt

FORDSON MOTOR TRACTOR: VIEW OF ENGINE FROM INTAKE SIDE

that many improvements can be made which will increase the capacity and efficiency of these tractors on Indian soils and thereby enable them to deal with a much larger area at a lower cost per acre. But to carry out all this work successfully, the co-operation of an engineer with agricultural knowledge is essential, and close collaboration with makers both of tractors and implements is essential and, when established, should prove of inestimable benefit to both sides. The low capital cost of these machines and their extreme handiness will render them admirably suited for Indian conditions, provided that they prove capable of withstanding the amount of ill usage which all machinery of this type will have to put up with in the hands of a race who make all adjustments with a hammer and all running repairs with a piece of string. The outlook at present for these machines is most promising, and I consider that they will make a big difference to agriculture in many parts of India if their early promise is fulfilled.

Miscellaneous. Seven hundred maunds of seed oats and 81 maunds of peas were supplied to Mesopotamia for seed purposes. This entailed a large amount of extra work in screening, cleaning and packing which the farm staff cheerfully undertook, and the whole consignment was despatched in record time and condition—an excellent achievement for which I take this opportunity of thanking all concerned.

III. Cattle-Breeding.

The combined herds totalled 372 head in the year under report.

It will possibly be advisable for the benefit of those who have not read former reports to state here the objects for which the two herds are maintained.

The Montgomery herd is divided into two portions—

(a) For selective breeding for milk production. The cows here are divided into five groups each with a separate bull; and the object is to breed up a first class milking strain in each group and thereby establish the breed without fear of in-

breeding. All the best milkers in the Montgomery herd are included in these groups.

(*b*) For crossing with the Ayrshire bulls. The cows here are not sufficiently good for inclusion under (*a*) and are used for putting to the Ayrshire bulls for the cross-bred herd.

The policy of strict selection for milk yield is being continued throughout the Montgomery milch herd and the best records among the cows in it this season were as follows :—

	lb.
Imani	5,654
Saheji	5,111
Anjani	4,953
Ladli	4,852

All Montgomery cows calving down for the first time are now being treated in English fashion, their calves being removed at birth and put on the pail. No difficulty whatever has been experienced in milking these cows without their calves, and I think this has given a pretty heavy blow to the idea that the indigenous cow will not give milk without a calf. Once she has acquired bad habits she is undoubtedly troublesome, but if her calf is removed at birth from her first calving she is as easy to deal with as an English cow, and if this practice is adopted by all who have heifers calving down they will save themselves much trouble. In two of the above cases calves have died, being weakly at birth. The advantage of having the cows continue giving milk instead of immediately going dry, as is the rule in such cases ordinarily, is too obvious to need emphasizing. I am also of opinion that possibly the tendency in Montgomery and indigenous cattle to stand off the bull throughout the milch period may be attributable to having the calf at heel, and it will be possible to collect some data on this point from the above experiments. They will also be of the greatest use in enabling us to start a set of absolutely reliable milk records. Our present method of averaging the teat the calf is allowed to suck is by no

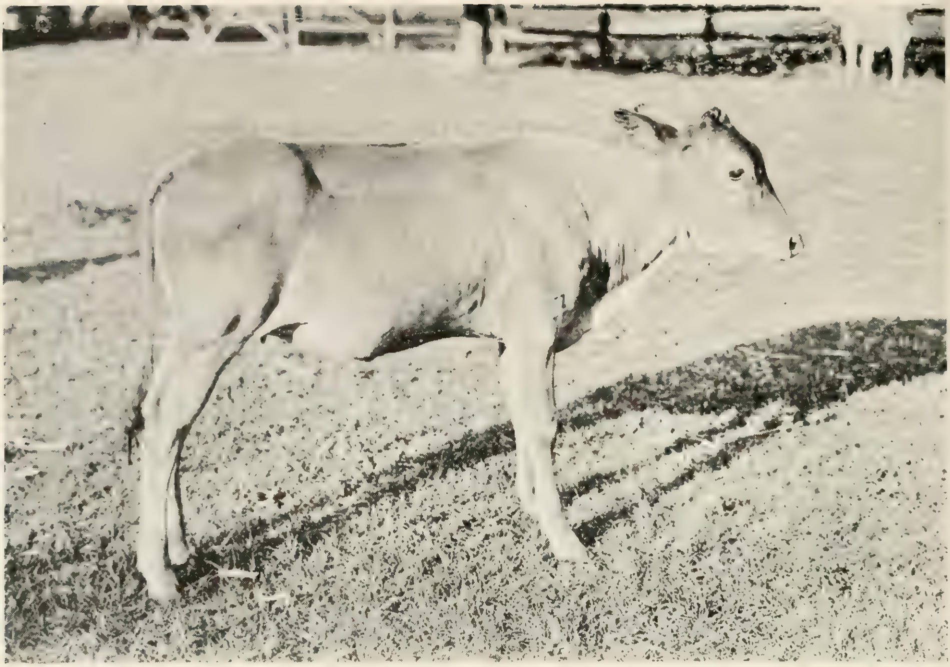

Fig. 1. Double cross cow-calf of Kitty No. 10; five months old.

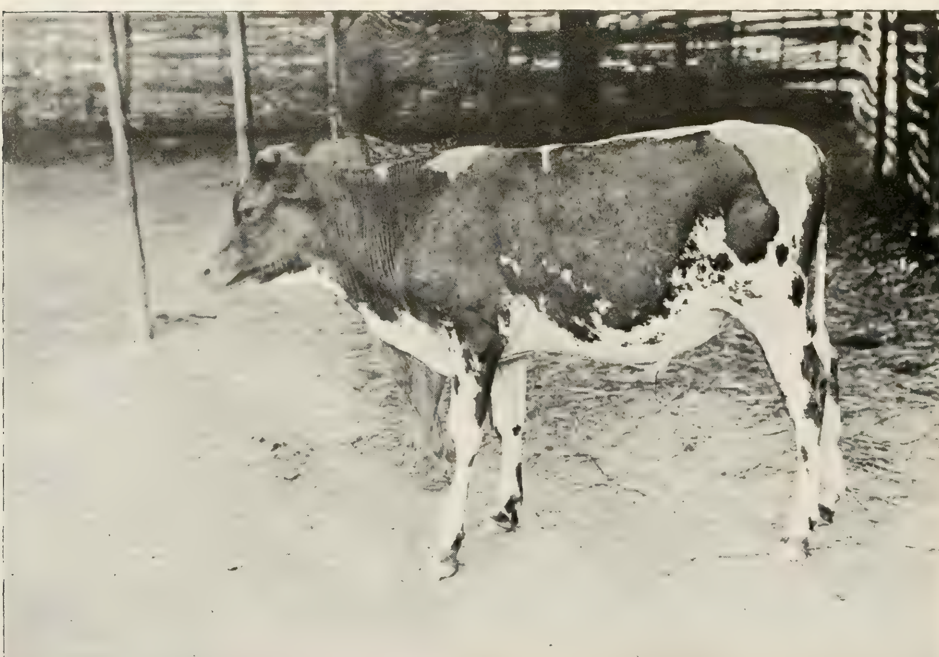

Fig. 2. Double cross bull-calf of Dollie No. 20; five months old.

means really reliable or accurate when it comes to a question of keeping proper milk records.

The Montgomery-Ayrshire cross-bred herd now stands at 73 head.

The heifers and cows in the herd are put to cross-bred bulls of which there are three with the herd :

(1) Black Diamond No. 3, by Mossgeil Titanic, out of Rengni No. 149.
(2) Goliath No. 8, by Lessnessock Wildfire, out of Diwali No. 77.
(3) Mammon No. 9, by Lessnessock Wildfire, out of Timki No. 80.

The Mossgeil half-bred bull is used on Lessnessock heifers and the Lessnessock half-bred bulls on Mossgeil and Carston heifers. A Carston half-bred bull will be added to the herd in place of one of the Lessnessock bulls as soon as possible.

We have now calves from the following crosses, and careful observations and records will be and are being kept with a view to collecting data as to hardiness, milk yield, etc.

Half-bred	Ayrshire bull × Montgomery cow.
Three-quarter-bred . . .	Ayrshire bull × Ayrshire-Montgomery cow.
Double cross-bred . . .	Ayrshire-Montgomery bull × Ayrshire-Montgomery cow.
Quarter-bred	Ayrshire-Montgomery bull × Montgomery cow.

Plate II shows two typical double crosses at five months, and Plate III, fig. 1 a three-quarter-bred at five months.

At present it appears that three-quarter-breds usually have a longer, thicker coat, and are apt to be rather slower doers at first than half-breds. They, however, do quite well in the later stages. It is practically impossible now to distinguish between half-breds and quarter-breds and, as far as the experiments have gone, it appears evident that

the half English blood in the half-bred bull is sufficient to produce the same English characters as regards appearance and build as the full English and it will be of interest to see if this holds good when tested at the pail.

The double cross-breds are in all points similar to half-breds and do equally well. The first lot of three-quarter-bred crosses which went through the December inoculation had a pretty stiff time which pulled them back a lot; but they are now doing well.

Experiments with half-bred bulls and country cows are now in progress, and this should enable us to collect data which will probably confirm results arrived at with the Ayrshire × Montgomery and pure Montgomery cross. The undoubted milking powers possessed by Montgomery cows being liable to mask any possible improvement in milk yield introduced by half-bred bulls which would probably show clearly in stock got from an ordinary country cow of a poor milking breed.

The full lactation yields for the six half-bred cows from Mossgeil Titanic were as follows and fully bear out the remarks made about them in last year's report :—

	lb.
Alibi No. 3	7,271
Daisy ,, 5	6,763
Naomi ,, 1	6,406
Pansy ,, 4	5,345
Nancy ,, 6	4,454
Biddy ,, 2	3,862

The yield of the last two cows was considerably reduced, by udder trouble in the first case while Biddy is shy of a teat.

These cows have now calved again and are, with the exception of the last two noted above, milking excellently.

Six Lessnessock Wildfire heifers have calved and are now giving an average of 18-20 lb. per day.

One Carston Royal Scotch heifer calved on 7th March, 1919, and is now milking well. The remarkable evenness of yield shown by all these heifers whether got from cows

Fig. 1. Three-quarter-bred bull-calf of Biddy No. 2, five months old.

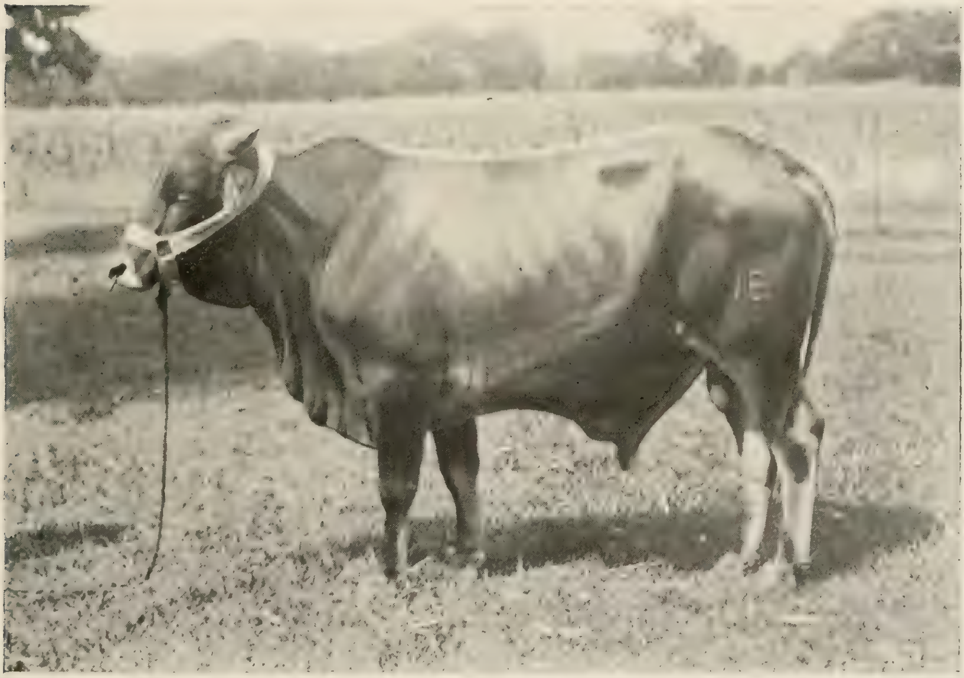

Fig. 2. Half-bred Ayrshire-Montgomery bull sold to the Hyderabad State.

PLATE IV.

A BUNCH OF THREE-QUARTER AND DOUBLE CROSS CALVES.

with good or bad milk records is a testimony to the potency of the English cross as regards milk production.

A series of calf rearing and feeding experiments have been started, and already show that half the usual quantity of milk fed to a calf during 10 months' lactation period, if given to the calf in the first five months only, grows a bigger, better calf at a far less cost. Plate IV shows a bunch of calves all taken clean off milk at five months. They are as big and strong as calves of 10 months and have been grown on half the quantity of milk fed to 10 months' calves which with milk at its present price is a big saving.

The usual couple of biennial sales were held in December, 1918, and April, 1919.

Seventy animals in all came under the hammer and realized a total of Rs. 11,850, averaging as follows :—

	Average price Rs.
Montgomery bulls	215
Montgomery cows	174
Montgomery bull-calves	126
Montgomery heifers	117
Ayrshire-Montgomery bull	500
Ayrshire-Montgomery heifers	455
Ayrshire-Montgomery bull-calves	146

Plate III, figure 2 shows a cross-bred bull sold to Hyderabad State for Rs. 500. These sales have now become an established custom, and the demand for all stock is so keen that I must again warn intending buyers to arrange to arrive in good time for sales.

At present every young bull I have to sell is being enquired about and Rs. 600 has already been offered in several cases.

Simultaneous inoculation. In December the whole of the young stock and all bulls—English, Montgomery and half-bred—together with all cows not heavy in calf were inoculated against rinderpest by the serum simultaneous method by Mr. Shilston, 169 animals being done. The

whole thing was a complete success in every way, and I take this opportunity of expressing my thanks for the invaluable assistance rendered by Mr. T. D'Sylva and the staff of the Power House, who stepped into the breach caused at the last minute by the strike of the entire *gowala* staff on religious grounds, and enabled me to carry out the inoculation. The way in which the staff turned to and soon proved that they could drive and stoke cattle as well as engines, enabled me to deal with the strikers drastically and future strikes of this nature are now extremely unlikely. A special inoculation camp was erected on the river bank at the most distant spot in the grazing grounds and cattle and attendants were kept there for the period of some six weeks.

The whole of the cattle were successfully inoculated and it was even found possible to save two of the control animals. The rest of the herd will be done this cold weather.

The sudden death of Mr. A. W. Shilston at Naini Tal from glanders was learnt with the deepest regret by the farm staff here, who had, during their month's work at the inoculation camp, every opportunity of seeing and experiencing the way in which Mr. Shilston carried on his work, and feel the loss occasioned by his death as keenly as those who had worked with him constantly.

Two young Montgomery bulls were introduced into the herd from the Military Dairy Farm at Ferozepore bringing in a much needed change of blood, and two Montgomery cows, one bull, and four calves were purchased from Bolpur. Various new buildings, including a set of calving pens and a building for the young male stock, were erected, and the thorough repair of the old buildings was started.

The general health of the herd was excellent and there was no outbreak of contagious disease during the year under record. I should like to take this opportunity of expressing my thanks to Khan Bahadur Judah Hyam who retires from Government service this August. He has had charge of the herd from the beginning and has seen it grow

into what is now the most famous herd of its kind in India; and it is in no small measure due to his care and experience in dealing with all forms of disease that it has been possible to bring such a state of things to pass, as a single outbreak of one of the more deadly forms of contagious disease would have easily destroyed ten years' work. And if there is one thing that constantly requires to be dinned into the ears of the owners of herds as well as subordinates in charge of them in this country, it is the necessity for extreme vigilance with stock uninoculated by the serum simultaneous method, and the necessity of taking prompt and effective measures against outbreaks of disease.

I give here the usual balance sheet for the breeding herd :—

Returns	Rs.	A.	P.	*Cost*	Rs.	A.	P.
Received for sale of milk .	6,677	13	3	Budget for upkeep . .	7,948	9	5
33 head sold in December auction	5,400	0	0	3,176 mds. 15 srs. grain at Rs. 3-8 per md. . .	11,117	5	0
37 head sold in April auction	6,450	0	0	Oil cake . . .	807	0	0
Sheep and cast stock . .	499	12	0	7,311 mds. green fooder at As. 4 per md. . .	1,827	12	0
TOTAL .	19,027	9	3				
Net cost	6,279	7	2	6,466 mds. *bhusa* and dry maize stalks at As. 4 per maund . . .	1,616	8	0
	25,307	0	5				
				5,306 mds. 13 srs. silage at As. 6 per md. . .	1,989	14	0
				TOTAL COST .	25,307	0	5

There was a considerable increase in the price of grain during the year, and that used for feeding cattle which was valued at Rs. 2-8 per maund in previous reports, has been charged for at Rs. 3-8 per maund this year.

The milk valuation, however, remains extraordinarily low at 10 Lahori seers (25 lb.) to the rupee. Cattle sales realized Rs. 11,850 for seventy animals which is a slight indication of the real value of the herd, as we naturally

keep the best stuff to breed from. The only conclusion which can be drawn from the above is that we have here a herd of great value which has now reached a stage in which it fully repays every rupee spent in improving, building, etc., and large extensions in the line of buildings and area will be imperative in the near future if the herd is to maintain its present progress.

I am constantly receiving enquiries from foreign Governments and Administrations regarding stock. To enable such enquirers to see what herds are kept at Pusa and the average number available for disposal each year, I propose to have a permanent advertisement in the "Agricultural Journal of India" giving these facts and other particulars.

Sheep. The attenuated garrison which held the fort at Pusa for some fifteen years against every disease under the sun, marched out of Pusa on 7th April, 1919, thereby terminating an experiment which has conclusively shown that the local conditions militate far too strongly against any attempt to improve fleece and mutton conjointly, as the improved cross immediately becomes liable to numerous diseases which do not seem to affect the local sheep, and an appalling death rate is the result. I use the word improved cross advisedly—as from the mutton fleece point of view. The spirit was doubtless willing but the flesh was uncommonly weak and the majority were never in such good condition as the local sheep. I may here say that such an experiment as the above carried on in a restricted area occupied by a large herd of cattle is liable to, and has possibly brought in, much disease; and it was the strong suspicion that such was the case, coupled with the impossibility of finding area for both cattle and sheep, that was partly responsible for the abandonment of the sheep experiments.

Miscellaneous. Plans have been put up for increasing the present veterinary dispensary. Over 8,000 patients were dealt with last year, which is straining the capacity of the place to the utmost.

I wish here to express my thanks for the way in which the cattle staff have worked. The work under their charge

has increased enormously and the inoculation camp which is now an annual event has added a heavy burden. This has all been cheerfully borne and the work has been excellently done. The reputation the cattle here now enjoy is in no small measure due to this continuous work and care.

IV. Programme for 1919-20.

Major.

I. (*a*) Practical treatment of pedigree dairy herd of Indian cattle and pedigree dairy herd of Montgomery-Ayrshire cattle.

(*b*) Continuance of experiments with regard to fixing a type of Montgomery-Ayrshire cross most suitable to Indian conditions.

II. Practical treatment of 1,200 acre mixed farm with particular attention to profitable modern machinery and the financial results of the work.

The bulk of the produce of the Pusa farm is used for the maintenance of the dairy herd. The rotation adopted aims at the up-keep of the fertility of the land along with supply of concentrated food and long fodder and a constant supply of green fodder throughout the year. Included in the above is the study on a practical scale of :—

(*a*) Rotations.
(*b*) Crops for fodder, seed and silage.
(*c*) Implements and machinery.
(*d*) Technique of cultural operations.
(*e*) Types of farm buildings.

III. Continuation of collection of data and results regarding the costs and capabilities of steam tackle on estates of this size.

IV. Experiments with various types of motor tractors and ploughs :—

(*i*) in comparison with steam tackle;
(*ii*) for collection of data and working costs;
(*iii*) for determination of most suitable type of tractors and implements for India—the co-opera-

tion of an agriculturist who is also an engineer is required here to enable these experiments to be thoroughly carried out;

(*iv*) collaboration with manufacturers regarding the manufacturing and introduction of any improvements in present types to suit Indian conditions.

V. *Experimental work at Pusa.* After the preliminary testing of the new experimental area at Pusa, the following will be started and continued along with existing work :—

(*a*) Rotational experiments.

(*b*) Trial of new varieties of existing crops, especially leguminous fodder crops and wheat varieties.

(*c*) Manurial experiments, especially seasonal and quantitative tests with phosphates.

(*d*) Rotation and manurial experiments already started.

(*e*) Seasonal tests with Java and Sumatrana indigo.

(*f*) Trial of sugarcane varieties suitable for growth without irrigation. (Some of Dr. Barber's varieties are very promising.)

VI. Demonstrations, exhibitions and sales of surplus dairy stock, etc., will be held from time to time as occasion offers.

Minor.

VII. *Touring and advisory.* Visits will be paid to provincial agricultural centres. This should tend to co-ordination of agricultural work.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(W. H. Harrison, D.Sc.)

I. Administration.

I availed myself of privilege leave from 4th July to 7th August, 1918, and during this period the First Assistant, Mr. J. N. Mukerji, was placed in charge of the Section. For the rest of the year I was in control.

Mr. J. Sen, Supernumerary Agricultural Chemist, continued on special duty under the Government of the United Provinces in connection with the opium investigations. His continued absence from his permanent post at Pusa entails considerable inconvenience to the head of the Section who, as a consequence, must necessarily give more attention to the routine analytical work than is desirable if material progress is to be made in research.

II. Education.

Mr. A. K. Mitra, who joined on 1st June, 1918, as a stipendiary student of the Bihar and Orissa Government, received tuition during the whole of the year under review.

III. Meeting of Agricultural Chemists.

The First Meeting of Agricultural Chemists was held at Pusa on 24th February, 1919, and the following days. The proceedings were opened by the Agricultural Adviser to the Government of India. The subjects placed for consideration before the meeting covered a wide field and comprised the drafting of a Fertilizer Act applicable to Indian conditions; the proposal of the Industrial Commission in regard to the formation of a chemists' service; standardization of analytical methods; the regulation of soil surveys and the necessity for the formation of groups of scientific officers for the specific study of specialized agricultural problems such as animal nutrition, soil biology,

etc. A report of the proceedings has been prepared for publication.

IV. Meteorology and drain-gauges.

The usual meteorological records were maintained, and in addition continuous records of the readings of wet and dry thermometers were instituted. The crops and drainage waters from the drain-gauges were examined in the usual manner.

V. General analytical work and assistance given to other sections.

The following samples were analysed and reported upon during the year :—

Soils	43
Manures	23
Feeding stuffs	13
Sugarcane	46
Gur (crude sugar)	1
Hide salt	3
Carbon bisulphide	3
Copper sulphate solution	17
Fungicides	2
Lead arsenate	1
Contents of stomach and intestines of a buffalo	1
Total	153

Among the items of interest in this connection, attention may be drawn to the number of feeding stuffs and fodders which were received for examination in relation to suspected cases of poisoning. In only one instance was the suspicion confirmed by analysis where a considerable proportion of prussic acid was obtained from a sample of linseed cake from a remount depôt. Acting upon the analytical report the use of this cake was discontinued when a complete cessation of the cases of poisoning occurred. The appearance of the cake suggested that it was the production of the ordinary country mill, and probably the expression of the

oil took place at a low temperature. The enzyme responsible for the liberation of the prussic acid from the cyanogenetic glucoside therefore remained undestroyed.

The following assistance was rendered to other Sections :—

Mycological Section. Seventeen samples of copper sulphate solutions were analysed in order to determine the loss of copper sulphate during the steeping of jute seed. Two samples of soils and three of fungicides were also examined.

Entomological Section. Twelve samples of soil and three of carbon bisulphide were reported upon.

Agricultural Section. Forty-one samples of sugarcane and thirteen manures were analysed.

Indigo Research Section. Six soils and four samples of manure were reported upon.

General. In compliance with the generally expressed wish of members of the Pusa staff the soils and subsoils of the permanent manurial experimental plots were carefully sampled and the variations in composition determined. These samples have not been included in the list given above.

VI. Methods of analysis.

The investigation upon the value of Dyer's method of estimating available phosphoric acid when applied to calcareous soils was referred to in last year's report, and the conclusions therein formulated have been confirmed. The problem of finding a suitable basis for the interpretation of the values obtained, or, alternatively, of evolving a new basis of comparison, has been merged in the wider investigation regarding the retention of phosphates in soils, and will be considered in that category.

Arising out of the recommendations of the Chemists' Meeting a critical study of the various methods of determining nitrogen in fertilizers has been undertaken.

VII. Mode of action of superphosphate in calcareous and non-calcareous soils.

In continuation of the investigation, reported last year, dealing with the reactions between mono- and di-calcic phosphates and calcium carbonate, attention has been directed to the retention of P_2O_5 in calcareous and non-calcareous soils, Pusa and Kalianpur soils being taken as the respective types. Formerly the phenomenon of retention by soils was explained as solely due to the formation of comparatively insoluble phosphates, but in later years the tendency has been to ascribe it largely to adsorption. In view of the facts that Pusa soil contains a very large proportion of $CaCO_3$, and that the mono- and di-calcic phosphates react with this substance, it seemed probable —even if the laws of adsorption were the determining factor in non-calcareous soils—that retention would be mainly due to chemical combinations in calcareous soils.

In order to test this, definite quantities of the type soils were shaken with a definite volume of solutions of superphosphate of varying concentrations, and the distribution of the P_2O_5 between the solvent and the soil determined. On plotting the logarithms of these values against each other it was found that, in the case of the non-calcareous soil, they lay upon a straight line, which is the criterion for adsorption. In the case of the calcareous soil the points lay along a sinuous curve; consequently adsorption is the determining factor in non-calcareous soils but not in calcareous soils.

A similar series of determinations with solutions of di- and tri-sodium phosphates showed that adsorption occurred in both calcareous and non-calcareous soils, and consequently the conclusion to be drawn is that the retention of superphosphate in the former type of soils is one of chemical combination.

A variation of these experiments was made by allowing one kilo of soil to remain in contact for one week, without shaking, with 450 c.c. of solutions of varying concentrations of superphosphate, and then determining the distribu-

tion of the P_2O_5 between the solvent and the soil. Under these conditions the results obtained with both types of soil were almost identical. This is explained by the fact that the Kalianpur soil contains a small proportion of $CaCO_3$ and as the proportion of soil taken was large there was sufficient $CaCO_3$ present to combine with the quantities of P_2O_5 taken. It may therefore be accepted that even small quantities of $CaCO_3$ can, under certain conditions, entirely mask retention through adsorption.

The conclusion arising out of these experiments is that the distribution, throughout the mass of the soil and immediate subsoil, of the P_2O_5 contained in a dressing of superphosphate applied to the type soils would be of a very different order in each case. To test this conclusion a definite amount of P_2O_5 dissolved in a known volume of water was allowed to percolate through a column of soil of 20″ depth contained in a glass tube. When percolation had ceased the tube of soil was cut into two inch sections and the amount of P_2O_5 retained in each section determined. An approximate determination of the P_2O_5 held in solution in each section and the P_2O_5 retained by the soil was also made.

In the case of the Kalianpur soil the percolate contained very appreciable quantities of P_2O_5, and the amount held by the soil varied from 12 per cent. of the original amount taken in the first layer of soil to 2½ per cent. in the lowest. The total amount of P_2O_5 (soluble and in solution) retained by any one section was in accordance with conditions demanded by adsorption.

The distribution through the column of Pusa soil was totally distinct. No P_2O_5, or only traces, were obtained in the percolates, and 69 per cent. of the original amount taken was retained in an insoluble condition in the first two inches and 76 per cent. in the first four, whilst practically no P_2O_5 penetrated to a greater depth than 12 inches. It is also noteworthy that the amount of P_2O_5 present in solution in the Pusa soil was very much less than the amount present in the corresponding section of Kalianpur soil.

The addition of 5 per cent. $CaCO_3$ to the Kalianpur soil brought about a distribution analogous to that obtained in

the Pusa soil, thus demonstrating the fact that this substance is the responsible agent of retention in the latter.

The general conclusions arising out of this investigation are (*a*) that the retention of P_2O_5 in calcareous soils is a different phenomenon to that of non-calcareous soils, (*b*) that the range over which applications of superphosphate are effective is wide in the case of non-calcareous soils but very restricted in the case of calcareous soils, and (*c*) that the principles underlying the employment of superphosphate in non-calcareous soils or soils of low $CaCO_3$ content are not applicable to calcareous soils, and that the conditions for effective phosphatic manuring in the latter require further close study.

VIII. The windrowing of sugarcane.

An Assistant was deputed to work at the Tarnab Farm, North-West Frontier Province, from December, 1918, to March, 1919, and during this period made numerous tests in order to follow the course of the changes taking place in the cane.

The scheme of experiment was as follows :—The sugarcane area was divided into three portions, the first of which was sampled and analysed on 18th December, 1918, and immediately windrowed. The second portion was sampled, analysed and windrowed on January 10th, and the remainder on February 3rd. It was possible, therefore, to institute comparisons between canes windrowed early and late, and at the same time by drawing representative samples the character of the changes which occurred in the windrowed cane could be determined at any time.

A study of the analytical data obtained showed that the total solids, as measured by Brix, increase during the period of storage, so that the juice becomes more and more concentrated as time goes on. At the same time the percentage of both glucose and sucrose increases, so that the juice of a windrowed cane contains a larger proportion of these constituents than does the original cane. On the other hand, the glucose ratio widens, and there is also a slight

increase in the proportion of "solids not sugar," so that a falling off in the quality of the juice is to be expected. That this is so is shown by the change in the co-efficient of purity, but this is not so great as might be expected, and in fact, owing to the increased concentration of the juice the variations in the percentage of crystallizable sugar are practically nil. Consequently the process of windrowing does not lead to any appreciable decrease in the amount of sugar obtainable from equal weights of juice.

It does not follow from the above, however, that there is no loss of sucrose and sugar so far as the crop is concerned, and this point can only be determined by careful weighments of the samples drawn and of the juice expressed. Such measurements were taken at each stage and the weights of sucrose, glucose, etc., calculated to the basis of 1,000 lb. cane when windrowed. The results obtained were remarkably concordant.

The amount of sucrose present in the cane windrowed on December 18th increased rapidly up to January 1st, and then remained practically constant until the first week in February after which there is a rapid decrease. The cane windrowed on January 10th showed a similar increase at first and again deterioration set in after the first week of February, whereas the cane windrowed on February 3rd showed only a continuous decrease. Similar fluctuations occurred with the weight of cane, weight of juice expressed, and are particularly well brought out in the case of crystallizable sugar. The weight of glucose, on the other hand, tends to increase uniformly.

All these comparisons show that cane can be stored by windrowing for some time, but that after a certain time has elapsed deterioration sets in. The date at which this first occurs is the same whether the cane be windrowed late or early in the season, and consequently would appear to be determined by factors which are either of a biological nature connected with the cane or to a seasonal one which affects all canes in a similar degree. It may, however, be pointed out that canes windrowed in December, 1917, showed no sign of deterioration four months afterwards, which

supports the theory that the determining factor is a seasonal one. This factor is one not easy of determination unless observations are extended over a series of seasons, but a comparison of the weather records for Peshawar for the seasons of December to March, 1917-18 and 1918-19, shows that the average temperatures were somewhat higher in the earlier season than in the later, and this would appear to throw out of court any question of temperature as being the real determining cause, although this is probably an important secondary factor. One comparison, however, is very significant and that is the date on which heavy rainfall was first experienced. In 1918 no rain of any meaning fell until the first week in March, and the canes showed no deterioration up to that time. Analyses made later showed the cane to be inferior. During 1919 a heavy downfall occurred about the first of February followed several days later by another heavy fall, and it is remarkable that this period marks the point at which rapid deterioration sets in. Thus during both years a falling off in the quality of the cane was first noticed during the period immediately following heavy rainfall, and this may consequently be provisionally selected as the seasonal factor which determines the length of the period during which canes may be safely stored by windrowing.

IX. Paddy manurial experiments.

A reference was made in last year's report to certain preliminary manurial experiments with paddy which were instituted in order to determine whether or not they could be successfully carried out under Pusa conditions. No insuperable difficulties were experienced but, as the sequel showed, it was an unfortunate circumstance that long-date South Indian paddies were selected. The paddy grew in a satisfactory manner but, although planted very early in the year, no flowering occurred until the cold weather had well set in, and as a consequence the seed formation was exceedingly poor and of no practical value for purposes of comparison. The vegetative yields were, however, satisfactory and may be utilized for this purpose.

Another noticeable feature was the fact that in a few isolated pots (about 6 per cent. of the total) a very abnormal growth took place, varying from 200 to 500 per cent. increase over the check pots in their particular series. These abnormalities occurred in pots containing green manure only, as well as in pots to which only ammonium sulphate had been added, and as the analysis of the soil gave no clue it is difficult to ascribe the result to any particular cause. I believe that other officers of the department have had a similar experience.

Eliminating these abnormal pots a fair comparison can be drawn. The underlying object of the experiment was to test the conclusion previously arrived at that green manures in relation to paddy cultivation mainly act in an indirect manner, and that their maximum effect would be experienced when they are employed in conjunction with direct manures. Nitrogen in the form of ammonium sulphate was taken as the variable mineral manure, and it was added in such quantity that each series contained nitrogen at the rate of 0, 20, 40, 80 and 160 lb. per acre as the case might be. To half the pots green manure was added at the uniform rate of 10,000 lb. per acre, so that a comparison of the effect of this quantity used in conjunction with increasing amounts of nitrogen could be determined. The average results were as follows, the crop values being given in grammes :—

Mineral manure added (rate)	Paddy No. 91 Madras			Paddy No. 24 Madras		
	Yield with ammonium sulphate only	Yield with ammonium sulphate and green manure	Increase due to green manure	Yield with ammonium sulphate only	Yield with ammonium sulphate and green manure	Increase due to green manure
No nitrogen .	84·6	135·5	50·9	139·8	150·3	10·5
N at 20 lb. per acre	93·8	146·8	53·0	155·3	174·9	19·6
N at 40 lb. per acre	97·7	155·8	58·1	192·8	199·3	6·5
N at 80 lb. per acre	140·9	203·6	62·7	194·9	236·3	41·4
N at 160 lb. per acre .	183·6	243·6	60·0	224·5	313·5	89·1

As this is a preliminary experiment, and is now being repeated under more stringent conditions, it is only necessary to point out that the increment due to the green manure tends to increase as the cropping due to nitrogen alone increases, thus giving some confirmation to the conclusions deduced from previous investigations.

A series of experimental pots have been laid down with the object of determining the comparative values to be ascribed to the direct and indirect action of green manures.

X. Miscellaneous.

At my request, my First Assistant repeated the laboratory experiments on which a portion of Memoir, Vol. II, No. 3, Botanical Series, "Note on a toxic substance excreted by the roots of plants," was based, using an artificial nutrient solution in place of the well water used by the author. Briefly, the method of experiment was to grow a large number of wheat, *arhar* (*Cajanus indicus*) and gram seedlings in the solution for a certain period of time, and then to allow the solution to evaporate spontaneously to one-third of its original bulk. A "blank" concentrated solution was also prepared by the evaporation of a solution in which no seedlings had been grown. It was found that the seedlings grown in this concentrated solution thrive much better than those grown in the "blank," thus offering no support to the theory of toxic excretion.

Samples of tobacco from experimental plots receiving different manurial treatment were examined for total ash, potash, chlorine, amido-nitrogen and proteid content, and it was found that, with the exception of chlorine, these values bore no relation to the treatment received. Tested for their burning value by Toth's method it was observed that tobacco manured with saltpetre burnt well but quickly, that with superphosphate treatment was much inferior. A combination of these manures produced a tobacco which burnt fairly well and not too quickly.

XI. Programme of work for 1919-20.

Major subjects.

1. Continuation of the investigations into the amount and nature of drainage water from fallow and cropped land.

2. Pot-culture experiments with paddy to determine (*a*) the relationship between the rate of drainage and crop production, (*b*) the direct manurial value of the nitrogen in green manures, and (*c*) the value of green manures when used in conjunction with nitrogenous mineral manures other than nitrates.

3. The mode of action of phosphatic manures in calcareous and non-calcareous soils.

4. A laboratory study of the changes occurring in windrowed cane.

Minor subjects.

1. Checking the accuracy of certain methods of analysis in confirmation to the general scheme drawn up at the Meeting of Agricultural Chemists.

2. A study of the conditions governing the formation of black alkali in soils irrigated by calcareous water.

XII. Publication.

Harrison, W. H. . Report on Agricultural Chemistry, 1917-18, for the Board of Scientific Advice.

REPORT OF THE IMPERIAL ECONOMIC BOTANISTS.

(A. Howard, C.I.E., M.A., and G. L. C. Howard, M.A.)

I. Introduction.

The Imperial Economic Botanist held charge of the Section during the year ending June 30th, 1919, with the exception of six weeks from October 22nd, 1918, which were spent on privilege leave in India. During this period, the Second Assistant, Maulvi Abdur Rahman Khan, was in charge of current duties at Pusa.

The work of the staff continues to be satisfactory. The Second Assistant has made himself very useful in connection with the improvement of the Botanical Area and in the experimental work in Central India and at Pusa. Chowdhry Ram Dhan Singh, B.Sc., Third Assistant, has worked well at the experiments in progress on indigo. This Assistant, on the recommendation of the Section, has been granted by the Government of India a stipend of £150 a year for three years with a free passage both ways to enable him to read for an Honours degree in Natural Science at Cambridge University. Babu Kashi Ram, Fourth Assistant, continues to do useful work in connection with the vegetable-drying experiments at Quetta and with the tobacco-breeding experiments at Pusa.

The difficulties in connection with the transport of seed by rail, referred to in the last report, increased considerably during the year. In consequence of the control of wheat which was rendered necessary by the shortage of supplies in India, the facilities granted last year by the Central Transport and Foodstuffs Board lapsed when that body ceased to exist. The system of priority certificates in force worked fairly well till the end of April when all movement of goods had to be restricted due to the exigencies of the military situation on the North-West Frontier.

A consignment of 3,000 mds. of Pusa 4, purchased for the Gwalior State to replace the country crop at certain centres in the famine-stricken areas of the State, unfortunately was only partially cleared by the railway before all civil transport became impossible. A very favourable opportunity for starting a new centre of distribution on the large scale with this wheat could therefore not be fully utilized. As the wheat could not be stored it had to be sold for local consumption before the rains set in. As soon as the Section possesses greater facilities, such difficulties can be surmounted by the simple device of storage in bulk and by the accumulation of large reserves which can be released as occasion demands.

II. Wheat.

Seed distribution in India. In the previous report, a detailed account was given of the progress made and of the means adopted in the substitution of the country wheats by Pusa 12 and Pusa 4. This work is being vigorously prosecuted and many new centres of distribution, including the Chin Hills in Burma and many of the Indian States, have arisen in various parts of the country. As usual, the amount of botanically pure seed available for starting these centres proved inadequate and little or no restocking of old ones was possible during the year. The area under Pusa 12 and Pusa 4 during the season of 1918-19 was estimated at half a million acres. The increased value of the crop, judged by numerous crop-cutting experiments, is at least fifteen rupees an acre so that the annual dividend on this portion of the work of the Section has already reached seventy-five lakhs of rupees (£500,000 sterling) and is rapidly increasing. As one year is too short a period to justify the time and trouble to all concerned in preparing a fresh summary of the position of these seed distribution schemes, progress will be recorded in the next report and in future in alternate years. In the present paper, the space so saved will be devoted to an account of some other aspects of these wheat investigations which have now reached the stage when they can usefully be discussed.

One very interesting example of a Pusa 12 replacement scheme entirely by means of unofficial agency should, however, be mentioned. This is the seed distribution scheme in the Simla Hill tracts in which Mr. H. E. J. Peake, the proprietor of the Khaltoo Fruit Orchards, and Sardar Narain Singh, Chief Secretary of the Sirmoor State, have interested themselves. In spite of the drought which last season ruined many of the fields sown with the ordinary crop, Pusa 12 did well. The number of villages growing this wheat rose from three to eight and the area increased nearly sevenfold. From small beginnings, a large bulk of seed has now been obtained which will facilitate the extended operations in progress. The aim is to establish a large continuous block of this variety in Sirmoor.

Intensive wheat cultivation. As pointed out in the last report, the substitution of the country crop by an improved variety is only the first step in raising wheat production in India to a higher level. The increased yields so obtained and the higher price per maund realized for the produce, are important means of establishing confidence and of setting up harmonious working relations between the Agricultural Department and the cultivators. The work of systematic substitution corresponds therefore to the duties of the advance guard of an army. The next step is the demonstration of the extraordinary response of superior types like Pusa 12 and Pusa 4 to improved soil conditions. It is here that the Agricultural Department will encounter its greatest difficulties and where it will eventually achieve its most striking triumphs. Briefly stated, the problem is the removal, in advance, of the factors which now limit production. A beginning has already been made in the direction indicated and results are beginning to appear. At Shahjahanpur in the United Provinces, Clarke has obtained 36·5 maunds of Pusa 12 to the acre, after sugarcane, in a year which was not particularly favourable. At Indore, on the black soils of the Malwa plateau, Coventry has obtained, on a plot of Pusa 4, 1·36 acres in area, sown on December 15th, a yield of 35

maunds of grain to the acre. In Bihar, Justin Finch, on an area of over 10 bighas, has obtained, under estate conditions at Mangalgarh, the record yield of $40\frac{3}{4}$ maunds of Pusa 4 to the acre. These figures indicate the potentialities of the soils of India and what can be done by the simple process of raising the content of organic matter and of increasing the internal surface of the pore spaces on which the wheat roots feed.

Pusa wheat in other countries. In previous years, small samples of Pusa wheats have been sent by post to correspondents in various parts of the world either for use in plant-breeding investigations or for direct trial. In many cases these samples have been worked up into large stocks and the wheats are now coming into general cultivation. In New South Wales, Pusa wheats regularly take prizes at the Royal Agricultural Show at Sydney and last year figured in the official account of the exhibits of the Easter Show published in the *Agricultural Gazette of New South Wales* of August, 1918. In West Australia, Pusa 4 has yielded over 30 bushels to the acre under field conditions and is considered there to be a rust-proof variety. In Uganda, Pusa wheats have been acclimatized and are being distributed by the Agricultural Department chiefly to European planters. In South Africa, Pusa 4 and Pusa 12 find a place in the list of varieties cultivated in the Union which was recently drawn up by the Agricultural Department. In Nigeria, extensive trials of Pusa 12 and Pusa 4 are in progress in the highlands of Sokoto, Kano and Bornu. Several small samples have recently been asked for from Canada, the United States, Brazil, the highlands of Java and the Soudan.

Water saving in wheat growing. During the year, the investigations on the water requirements of the wheat crop which have been in progress since 1912 have been summed up in the new edition of Quetta Bulletin No. 4—*The saving*

of irrigation water in wheat growing—the first edition of which appeared at the end of 1915 and which has been out of print for some time. At first, these investigations were confined to the Quetta valley but during the last three years they have been extended to the important wheat growing tracts of North-West India. The results obtained are so definite and the direction in which wheat production in these areas can be improved is so clearly indicated, that it appears desirable to take this opportunity of summing up the present position of these investigations.

The Quetta experiments fall into two stages. It was first found that, on roughly levelled land, a crop of from 15 to 20 maunds of grain to the acre could be grown on one irrigation, applied before sowing, provided care was taken to obtain a good tilth and to break up rain crusts during the winter and spring by means of the lever harrow. This is considerably more than the yields obtained by the zamindars on similar land with six or seven irrigations. In the second stage, a further increase in the duty of water was secured. This was obtained by carefully grading the land[1] and by the employment of a leguminous rotation. In 1918-19, on land carefully graded and after a summer fallow preceded by a cold weather crop of clover, a yield of 32 mds. 27 seers (2,686 lb.) of grain and 57 mds. 13 seers (4,715 lb.) of straw was obtained on an acre plot on the preliminary watering only. The land was irrigated before sowing on October 12th and cultivated lightly with the spring tine cultivator followed by the beam on October 16th as soon as ever the surface was dry enough for this purpose. Under the thin mulch so produced, the soil dried slowly and yielded a perfect tilth when it was ploughed with iron ploughs on October 19th. Before ploughing, the

[1] The details relating to the method of levelling adopted and to the system of irrigation for alluvial soils worked out at Quetta are described in Quetta Bulletin No. 7—*The irrigation of alluvial soils*—published in 1916.

seed was scattered broadcast on the surface and after the whole area was ploughed once, the beam was run over the land both ways. Besides the saving in cattle power, this method of combined tilth production and seed covering, by means of the iron plough, involves the minimum loss of moisture. Afterwards, rain crusts were broken by the harrow seven times, the last operation taking place on April 15th, 1919. Side by side, about three acres of similar land which was only roughly levelled and which had not borne a clover crop were treated in the same way. The yield in this case was much lower—19 mds. 31 seers (1,625 lb.) of grain and 33 mds. 15 seers (2,745 lb.) of straw to the acre.

In 1916, a beginning was made in the application of the methods worked out at Quetta to the conditions of North-West India. The first results were obtained in 1917 on the estates of Rai Bahadur Ganga Ram, C.I.E., M.V.O., and Rai Bahadur Sewak Ram at Gangapur and Haripur in the Lyallpur District and at the seed farm at Sargodha in the Jhelum Colony. The preliminary irrigation gave nearly ten maunds of wheat to the acre, one additional watering after sowing yielded a little over sixteen while three irrigations reduced the yield appreciably. At Mirpurkhas in Sind, where the texture of the soil is finer than that of the Canal Colonies of the Punjab, Main[1] obtained still better results. After a deeply cultivated hot weather fallow and a double irrigation in the latter half of October, *pissi* wheat on stiff working soils gave over 19 mds. (1,533 lb.) to the acre. On similar land which received in addition one irrigation in January the yield was 23⅔ mds. (1,894 lb.) per acre. Under the local Sindhi methods, four or more waterings would have been applied to the standing crop. Other comparative results obtained the same year in the manner described above are summarized in Table I.

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[1] Main, T. F. *Agricultural Journal of India*, vol. XIII, 1918, p. 653.

TABLE I.

Water saving results obtained at Mirpurkhas, 1916-17.

Variety	Area in acres	Yield of grain in lb. per acre: One watering after sowing	Yield of grain in lb. per acre: No watering after sowing	Remarks
Pusa 12	The comparisons were made on half plots measuring 1 to 1½ acres per plot	1,333	1,172	Soil somewhat stiff.
Pissi		2,048	1,533	
Pusa 12		1,116	970	Light, free-working soil.
Pusa 12		1,600	1,680	
Pusa 12		1,418	2,062	
Pusa 12		1,718	1,633	
Pusa 12		1,067	1,333	
AVERAGE		1,471	1,483	

It will be seen that taking all the results in this table together, the extra watering, on the average, not only produced no result but slightly depressed the yield. Taking the results on the light, free-working soils only, the average yield on the preliminary watering comes to 1,535 lb. per acre while that with the extra January irrigation is only 1,383 lb. per acre. Thus on a soil with good texture, the second irrigation depressed the yield by no less than 152 lb. per acre.

The most striking results on water saving so far obtained in the plains of North-West India were secured by Clarke at the Sugar Experiment Station at Shahjahanpur in 1919 after the poor monsoon of 1918 (Plate V). The rainfall of June, July and August amounted to 21·9 inches and there was practically no rain during September and October. The wheat (Pusa 12) was sown on natural moisture in October and was irrigated once only in November. The cold weather rainfall was 2·63 inches all of which was received in January, 1919. The yields obtained

PLATE V.

PUSA 12 GROWN WITH ONE WATERING AT SHAHJAHANPUR.
Area 3·4 acres—yield 36·5 maunds per acre.

are given in Table II. The sample of grain was a very fine one with the uniform texture which millers so much appreciate.

TABLE II.

Yields obtained with Pusa 12 at Shahjahanpur with one irrigation, 1918-19.

Previous crop	Area in acres	Total yield of grain in maunds	Yield per acre in maunds
Sugarcane in trenches	3·4	124	36·5
Sugarcane mostly on the flat, a little in trenches	7·4	233	31·5
TOTAL	10·8	357	AVERAGE 33·1

Taking all these results together, two principles stand out clearly. In the first place, it is evident that a fair wheat crop in North-West India can be obtained under ordinary conditions and on ordinary land by means of the preliminary irrigation only. In the second place, if the texture of the soil has been improved and if the surface has been properly graded (as was the case in the Quetta and Shahjahanpur experiments of 1918-19) the duty of water is very greatly increased and extremely heavy crops are possible with a comparatively small volume of irrigation water. Further waterings in these two experiments would have produced no useful result as the grain in both cases was well filled and the yield had already reached the limits imposed by the standing power of the varieties grown. The establishment of these two principles leaves no doubt as to the main direction of improvement in wheat production in North-West India. A portion of the wheat and gram grown should be raised on the preliminary irrigation only supplemented by the winter rains or at the most by one additional watering. The water thus set free should be used for the production of leguminous fodder

crops like lucerne, *senji* (*Melilotus indica*), berseem and *shaftal* (*Trifolium resupinatum*). Most of these can be made into excellent hay and can be baled, either separately or mixed with an equal amount of *bhusa*, for transport purposes. For some years past, trials of these fodders have been carried out in the Fourth Division at Quetta, the results of which prove that by their use the weight of animal food carried by an Army on active service can be reduced by at least one-third with some reduction in cost. Similar advantages would be obtained in ordinary road transport. The general improvement in the organization of the local fodder supplies would go far to solve the cattle and milk problems and would also increase the supply of manure. A large nucleus of dried leguminous fodder in North-West India would also be an advantage in time of famine when one of the problems is to rail into the affected areas sufficient forage to save the lives of the cattle. These leguminous fodders give the best yield if the land is well manured. If, therefore, the zamindar were to put up to a fifth of his land into these fodders every year and were to concentrate his supply of manure on this area, this valuable rotation would rapidly improve the texture of the soil. This in turn would increase the yield of wheat and would also raise the duty of water. A great impetus will be given to this work when the Army take up leguminous fodders for transport work on similar lines to those recently adopted in Egypt where about 150,000 tons of berseem hay were baled for the use of the Armies of Palestine and Salonika.

The breeding of rust-resistant varieties. An important stage in the breeding of rust-resistant wheats for India has been reached. This work was started in 1910 at Cambridge where a number of Indian pure lines were sown as spring wheats and crossed with some of Professor Biffen's new rust-resistant hybrids. From the crosses so obtained many new forms have been fixed at Pusa which are characterized by strong straw, rust resistance, good standing power and heavy yield. These are now being tested on a

field scale and are yielding very promising results. Unfortunately some of the Pusa 6 crosses have inherited one defect, namely, their inability to hold their grain for a long period in a dry season. To remove this they have been re-crossed with short-strawed, rust-resistant Indian types of high grain quality which hold their grain well. From the crosses so obtained it is expected that ideal types suitable for the damper wheat-growing areas of India will be obtained. It must be remembered that rust-resistance by itself is of little economic value. It is only when this character is combined with a large number of others that it becomes of use to the country. If the wheat rust problem, as is sometimes thought, consisted only in the isolation of rust-resistant types this portion of the wheat investigations at Pusa would long since have been completed. The problem before the plant breeder, however, is much more difficult than this.

Trials of new Pusa wheats. The trials, on a field scale, of some of the new series of Pusa wheats which were begun in 1917-18 have been continued during the last year. Those at Kalianpur and Cawnpore were carried out by Mr. B. C. Burt while the Pusa tests were made in the Botanical Area. The results are given in Table III.

TABLE III.

Trials of new Pusa wheats at Pusa, Cawnpore and Kalianpur, 1918-19.

Variety	Pusa	Cawnpore	Kalianpur	REMARKS
Pusa 12 . . .	—	2,230	2,143	In all cases yields are expressed in lb. per acre.
Pusa 31 . . .	1,974	1,910	1,708	
Pusa 36 . . .	2,139	1,940	2,061	
Pusa 37 . . .	2,221	2,020	2,009	
Pusa 43 . . .	2,496	2,150	2,170	

Trials of new Pusa wheats at Pusa, Cawnpore and Kalianpur, 1918-19—contd.

Variety	Pusa	Cawnpore	Kalianpur	Remarks
Pusa 44 . . .	2,496	2,210	2,072	
Pusa 45 . . .	2,433	2,280	2,001	
Pusa 4	2,102	2,130	2,168	
Cawnpore 13 . . .	—	—	1,668	

The trials are being repeated as the season of 1918-19 in the *Doab* was abnormal. The monsoon was a failure at Cawnpore while hot winds during the ripening period lowered the yield of the later kinds very considerably.

III. Indigo.

In last year's report, a somewhat detailed account was given of the work in progress on Java indigo. This dealt with a study of the conditions necessary for growth and for seed formation, of the factors of importance in root development and of the principles underlying improvement by selection. These investigations are being continued and extended. During the past year, a number of interesting results have been obtained many of which bear on the practical aspects of the industry.

Indigo wilt. One of the difficulties encountered in the cultivation of Java indigo in Bihar is a condition known as wilt. After the middle of the monsoon, it often happens that the Java plant ceases to thrive, growth slows down, the foliage changes colour and afterwards becomes progressively reduced in amount. This is followed by the gradual death of the plant. Associated with the wilted condition during this period is extensive destruction of the fine roots and nodules. As there appeared to be a connection between the rise of the subsoil water in Bihar (Plate VI) and the development of wilt, a series of lysimeter experiments was carried out in 1918 in order to determine whether or not there is any relation between waterlogging

from below and the appearance of this trouble. The lysimeters consisted of cemented tanks, $\frac{1}{1000}$ of an acre in area, built above the ground level and provided with drainage openings which could be closed or opened at will. Two series of three lysimeters were constructed. One set was filled with soil from the Kalianpur farm near Cawnpore, the other with light Pusa soil. The Kalianpur soil is exceedingly rich in available phosphate (0·318 per cent.) while Pusa soil, when analysed by Dyer's method, gives very low figures for available phosphate (0·001 per cent.). The results obtained were as follows :—

(1) In both Pusa and Kalianpur soil, the indigo in the lysimeters with free drainage escaped wilt.

(2) When the drainage openings were closed and waterlogging from below took place, all the plants were wilted in both Kalianpur and Pusa soil.

(3) The wilt in the Kalianpur soil (rich in available phosphate) was much more pronounced than in Pusa soil (said to be low in available phosphate).

(4) The growth in Kalianpur soil was much slower than in Pusa soil.

(5) The stoppage of drainage brought about an interesting change in the root system of the indigo and caused the laterals to run near the surface.

Root development. The systematic examination of the root system of this crop throughout the year, in various soils and under different conditions of growth, continues to yield interesting results. This work is still in progress and is not likely to be completed for some time. The effect of previous waterlogging on stiff soil on the root system is very marked. Five months after sowing, equal areas on the the waterlogged and control plots were taken and the heights of the plants were measured. On the waterlogged plot, the average height of 200 plants was 10·4 cm., on the control the average height of an equal number of plants was 28·0 cm. When the root system of the plants on these plots was examined, it was found that the first effect of

waterlogging was to restrict the roots to the upper layers during the first few months of growth and to change the general character of the root system. The development of the tap root is soon arrested and later in the season one of the laterals after bending takes its place. When the subsoil is more porous, the effect of waterlogging before sowing is less.

Selection. An important discovery has been made and utilized in the selection work in progress on Java indigo. Some time ago it was observed that if any set of August sown seed plants is cut back during the early hot weather, there is a great range in the capacity of the individuals to form new growth. There is every gradation between abundant and rapid new growth and the development of weak wilted branches.

Seed production. For the fifth year in succession, the continuous Java indigo plot in the Botanical Area yielded a fine crop of seed in spite of an unfavourable season due to the heavy rains in August just after sowing and to the early cessation of the monsoon in September. This plot has never received any artificial manure nevertheless the seed crop continues progressively to improve. A good crop was also obtained on a field lent by the Dholi Estate. In this case also no artificials were applied to the land and the present is the third crop of indigo seed which has been raised during the last three years.

In connection with these field results, the effect, on the growth and seed formation in this crop, of alterations in the soil texture was investigated by the modified system of pot culture described in a paper read at the Indian Science Congress at Lahore.[1] In this method, the soil conditions down to a depth of two feet can be altered by the addition of such aerating materials as sand, broken tiles and leaf mould or a combination of these substances. The effect on the growth and seed formation is given in Table IV where the results are expressed in grammes in terms of 50 plants.

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[1] *Agricultural Journal of India,* Special Indian Science Congress Number, 1918, p. 36.

TABLE IV.

The effect of altered soil texture on growth and seed formation in Java indigo.

Soil treatment	Weight of dry stems (excluding leaves)	Weight of dry seed
1. Control (soil disturbed)	68	32
2. Soil 1/2 + sand 1/2	127	70
3. Soil 9/10 + potsherds 1/10	118	92
4. Soil 8/10 + potsherds 2/10 . . .	141	94
5. Soil 7/10 + potsherds 3/10 . . .	136	89
6. Soil 4/10 + potsherds 3/10 + leafmould 3/10.	744	511
7. Soil 7/10 + leafmould 3/10	907	577
8. Soil 5/10 + postsherds 2/10 + leafmould 3/10.	905	595
9. Soil 6/10 + potsherds 1/10 + leafmould 3/10	715	685
10. Control (soil disturbed)	72	32

An inspection of the table shows that while the substitution of ten to thirty per cent. of the soil by potsherds multiplies the yield of seed three times, the effect of leafmould with or without potsherds was much greater. Thus the substitution of forty per cent. of the volume of the soil by leafmould (30 per cent.) and potsherds (10 per cent.) increased the production of seed twenty-one times. Another interesting feature was the cessation of growth in length in all cases at the beginning of December quite independently of the soil conditions or of the size of the plants. This always occurs under field conditions. For large yields of seed, large plants must be produced by the beginning of December and practically all the seeds must have set by this time. Bearing in mind the small amount of growth which is possible up to the beginning of October, it is evident how rapid the development must be during October and November if crops of seed over ten maunds to the acre are contemplated.

The growth of indigo. A large amount of careful experimental work has been carried out on the conditions necessary for the establishment of the ordinary crop. Sowing should be done early—if possible before the *hathia* in the beginning of October—and the land should be clean fallowed and well cultivated beforehand. Later sowings are nothing like so successful. As regards the soil conditions necessary, the addition of moderate dressings of organic matter, applied in the hot weather or on the early rains, greatly assists in the establishment of the seedlings and in the early growth of the crop. If sown on very poor land, it has always been observed that Java indigo establishes with great difficulty and that numerous blank spaces occur. These results indicate the need of combined nitrogen for the early growth of this leguminous crop. This was confirmed by the behaviour of indigo on plots uniformly manured with 15 maunds of oilcake to the acre, a portion of which was waterlogged for a month before the crop was sown. It is known from previous experience of the Pusa soil that waterlogging for a month during the late monsoon is sufficient to bring about extensive losses of combined nitrogen through denitrification. On the waterlogged portion of the plot, the indigo grew with great slowness at the beginning compared with the control and this difference has always been maintained through the hot weather. Thus the field results as well as those secured by the modified system of pot culture, all point to the need of combined nitrogen in establishing a good stand of Java indigo. On the other hand, it is well known that heavy dressings of substances like *seeth*, oilcake, and farmyard manure stimulate vegetative growth at the expense of indican formation, a process which takes place best if the plant is grown on land somewhat on the poor side. An interesting field of investigation is therefore indicated. It may be found to pay to stimulate the crop a little by means of organic matter so as to establish it rapidly and strongly even if the yield of indican per 100 maunds of green plant is thereby slightly reduced. The increased produce of indigo per acre might

be found to pay. Such a matter however cannot be settled by experiments on small plots on account of the well known difficulty in Bihar of obtaining even land to the depth made use of by this crop, and of manufacturing small lots of green plant. It is a matter which will have to be decided by general experience of work under estate conditions. Possibly the easiest and most economical method of testing the point would be to manure for the previous crop and to raise the indigo on land in fair condition.

IV. Drainage and crop production.

In the report of 1917-18, the bearing of the soil aeration factor on flood irrigation, as practised by the cultivators in North-West India, was discussed. It was shown that successful irrigation involves more than the mere application of water and that the aim of the irrigator should be *the provision of water in such a manner as to interfere as little as possible with the aeration of the soil.* At the meeting of the Indian Science Congress at Bombay early this year, another aspect of soil aeration was dealt with, namely, inadequate drainage—a matter of particular importance in many parts of India. Over large areas nourished by the monsoon this factor bars progress. Its removal, however, is a matter which often lies outside the scope of the Agricultural Department and its mere consideration involves a multitude of other interests—those of the cultivator, the landowner, the revenue authorities, the engineer and the sanitarian.

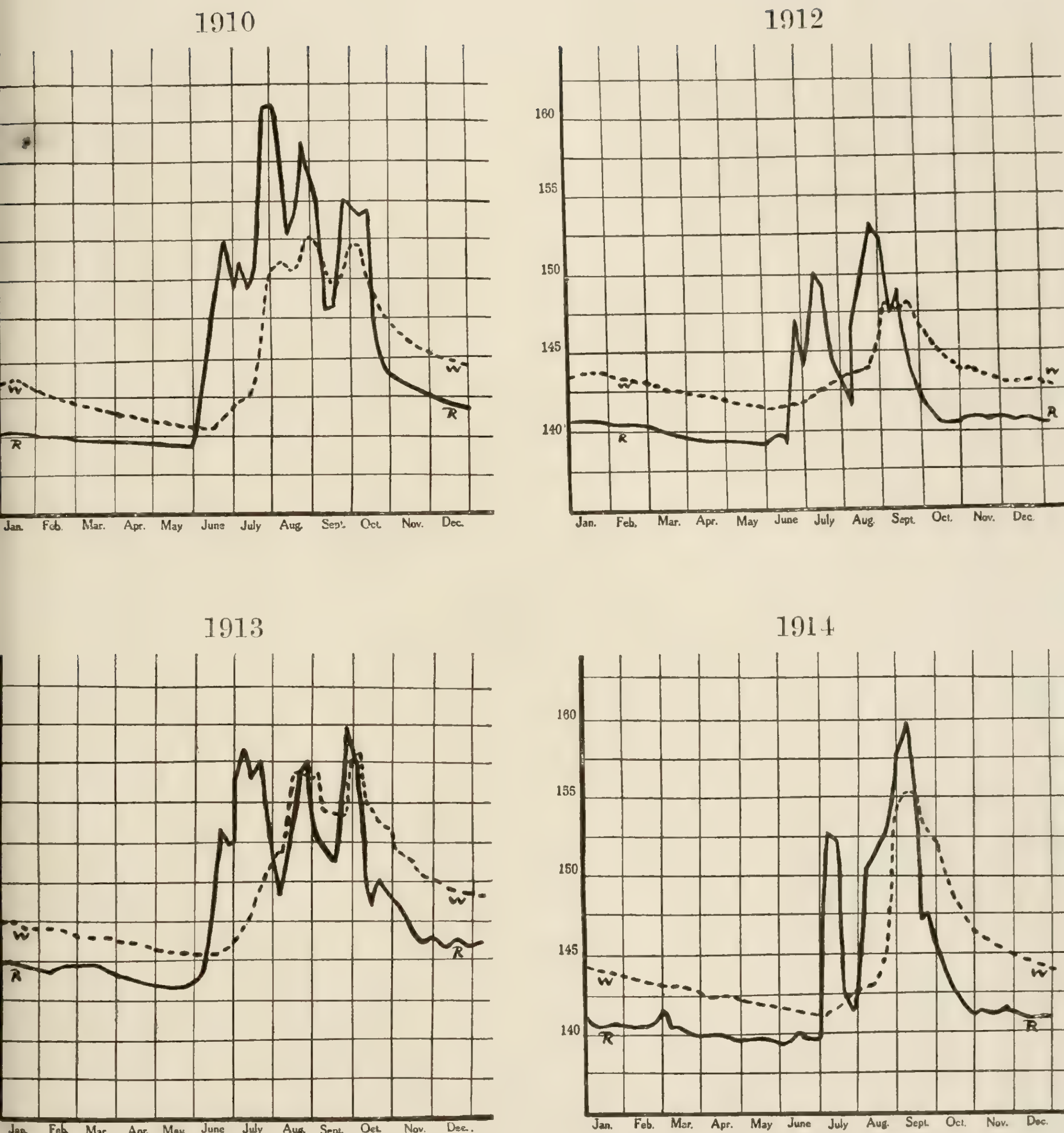
In the plains of India, defective drainage arises during the monsoon from two distinct causes. In the first place, when the soils are on the stiff side, local accumulations of rain water rapidly lower the fertility. In the second place, the subsoil water often rises to such an extent at a time when the flow of the rivers is impeded that little or no general drainage is possible over large tracts of the alluvium.

Surface waterlogging has been found to affect growth in two ways—by the destruction of available nitrates and

by a profound alteration in the physical texture of the soil. When the land dries after a long period of surface water-logging, it is difficult to obtain the ideal crumb structure and to provide sufficient room in the soil for root development. The clods do not readily break down under the beam and the soil is gummy to the feel. Colloidal substances appear to be formed under these anaerobic conditions which not only hinder the formation of a good tilth but also prevent percolation. It is quite common at Pusa after a very heavy monsoon to find the pore-spaces near the surface almost entirely filled with water for some considerable time after the level of the rivers and of the ground water has begun to fall. The surface soil does not seem to be able to drain. An improvement in the texture follows if the surface drainage is improved and in cases where organic matter has recently been added to the soil. The gummy substances do not then seem to be formed to any great extent and the clods readily break down. These matters require exact and careful investigation and it is difficult to suggest a more promising field of work for the soil physicist in India.

The effect of the rise of the subsoil water in preventing drainage is well marked in North Bihar after the monsoon has set in. The flow of the local rivers is soon checked by the rise of the level of the Ganges. As a result, the rivers overflow and the low-lying areas go under water. The rise in the level of the rivers is followed by a rise in the water-level of the wells. These movements of the river-level and of the general ground-water are illustrated in the curves opposite (Plate VI) which represent the condition of the river at Pusa and of one of the wells (about a quarter of a mile distant from the river bank) for the years 1910, 1912, 1913 and 1914. It will be seen that the curves of the ground-water level vary according to the year. In some years like 1912 and 1914, the curve is even and no great oscillations of level occur. In others, such as 1910 and 1913, there are well-marked oscillations. These oscillations, from the plant's point of view, are of the greatest

PLATE VI.



CHANGES IN THE RIVER AND WELL LEVELS AT PUSA.

The well levels are shown by dotted lines
The observations are expressed in feet
above mean sea level.

importance as a fall in the level of the ground-water means a strong downward pull and the temporary resumption of drainage and of soil-aeration. In interpreting field experiments therefore in the monsoon, the amount of drainage which is possible may easily prove to be an important factor.

The effect of improved surface drainage on crop production has been found to be very considerable in the Botanical Area at Pusa. Not only is the loss of nitrates by denitrification greatly reduced but good drainage, combined with the checking of erosion, has had the effect of maintaining the fertility with a comparatively small expenditure of organic manure. The behaviour of two typical plots in the Botanical Area brings out this point clearly. In the case of plot 10, one and three-quarter acres in area, a typical wheat soil of rather heavy texture, the records show that during the last 15 years this field has produced 13 heavy cereal and 2 good pulse crops while the manurial treatment has consisted only of three green manurings with *sanai* (*Crotalaria juncea*) and a single dressing of castor cake at the rate of 15 mds. per acre. The present condition of the land shows that it has improved under the treatment. In 1919, yields of over 30 mds. of wheat to the acre were produced in a season which did not favour heavy crops. Another plot, No. 1, of somewhat lighter land and about one acre in area, has given, since 1905, 10 good crops of cereals, three of pulses and two of indigo seed. The manuring for these 15 heavy crops consisted of three green manurings, a total of 15 tons of farmyard manure per acre and a single dressing of 10 maunds of oilcake to the acre. The wheat crop of the last year was over 29 mds. per acre, the highest so far given by the area. Here again the land has increased rather than decreased in fertility. Similar experience has been obtained at Quetta where an area of land about 3 acres in area has been continuously cropped with wheat without manure since 1912. The wheat is raised on a single irrigation applied before sowing and

after the crop is reaped, care is taken to plough up the stubbles and to expose the soil to the sun and air during the summer months. The yield in 1919 was just under 20 mds. per acre, the highest so far obtained. Results such as those quoted above indicate that alluvial soils, if properly managed, do not require large quantities of organic matter to keep up their fertility. That such yields can be obtained at all indicates that nitrogen fixation in these soils must be much greater than is commonly supposed. The results obtained in the Botanical Area at Pusa and on the seed farms in the United Provinces clearly indicate that any fears of soil depletion in the plains of India are groundless. Increased rather than decreased yields are to be expected as surface drainage is improved, as erosion becomes checked, as the texture of the land is improved by the extended use of suitable leguminous rotations and as the conditions necessary for nitrogen fixation are elucidated and applied.

V. The sun-drying of vegetables.

The work in progress at Quetta on the sun-drying of vegetables has been extended considerably. Towards the end of last year (1918) this product was placed on the market for the first time at Quetta and also at Calcutta. About 1,500 half-pound tins were prepared which found a ready sale. The demand at Quetta was extraordinary. The orders amounted to about 20,000 tins of which only about five per cent. could be met. The principal purchasers were the engineering parties engaged on the Nushki Extension Railway and the various regiments operating in Mesopotamia and Persia.

An exhibit of Quetta sun-dried vegetables was arranged at the Medical Conversazione at Parel held in connection with the Bombay meeting of the Indian Science Congress. As usual, this attracted the attention of a large number of visitors. It also led to the establishment of an agency in Bombay for the sale of the product. The exhibit was afterwards shown at the Lucknow Flower Show.

During the present year (1919), the production of sun-dried vegetables at Quetta has been increased and seven selling agencies in India, in addition to the one at Quetta, have been stocked. The cost of production has been considerably reduced and the work accelerated by the use of power peeling and slicing machines imported from England. These have proved very successful and easy to operate.

The preliminary results obtained on the anti-scorbutic and anti-beri beri properties of sun-dried vegetables were communicated by Captain Shorten, I.M.S., Professor of Physiology, Medical College, Calcutta, to the Medical Section of the Indian Science Congress at Bombay. This aspect of the work has since been considerably developed and it is expected that the experiments will be completed during the present year.

VI. Fruit packing.

The sale of improved fruit boxes to the trade at Quetta continues to be satisfactory in spite of the delays on the railways resulting from the military situation on the Frontier in 1918 and 1919. It was expected that this cause would be sufficient to put an end to the business for the time being but the demand continues to increase and the boxes are sold off as fast as they can be prepared. One encouraging feature is the increasing tendency on the part of the dealers to purchase the well made strong crates holding 24 punnets which are now returned free of charge from all stations in India to Quetta and Chaman and which can be used many times. These are sold for Rs. 5-8 each and are taken up readily. It is quite safe to say that seven years ago when this work was started, not a single returnable crate would have been bought by the dealers. They have since found by experience, however, that it pays to put money into better packing and to adopt a system by which damage in transit is reduced to a minimum.

VII. Tobacco, fibres and gram.

Tobacco. The demand for seed of Type 28 continues to increase both for general cultivation and for cigarette purposes. Indents for about 5,000 acres of new cultivation were dealt with which has exhausted the whole of the supply of seed. A number of late indents have been transferred to 1920. An effort will be made this year to grow a larger stock of selected seed. In addition to applications for seed, a number of correspondents have asked for samples of cured leaf. It was impossible to supply any of these as all the land available was used for producing seed.

Fibres. In addition to its suitability for India, the improved type of *patwa* (*Hibiscus cannabinus* L.) known as Type 3, is doing well in other countries. After the preliminary trials, the Agricultural Department of the Union of South Africa cabled for five tons of seed of this variety. Only a hundred pounds could be spared and so the opportunity for introducing this type on a large scale into South Africa was lost.

Gram. A comparative trial at Pusa of some of the more promising types of gram gave the following results :—

	Mds.	Seers	
Type 17	29	32	per acre.
Type 18	27	37	,, ,,
Type 6	27	22	,, ,,
Type 23	26	25	,, ,,
Type 25	25	15	,, ,,

A considerable demand for seed of some of these types has arisen, a small portion only of which could be satisfied.

VIII. The pollination of Indian crops.

A further paper dealing with the pollination of Indian crops was prepared for publication during the year. In this the following crops were considered—San hemp (*Crotalaria juncea* L.), pigeon pea (*Cajanus indicus* L.), Java indigo (*Indigofera arrecta* Hochst.), Sumatrana indigo (*Indigofera Sumatrana* Gaertn.), linseed (*Linum*

usitatissimum L.), *taramira* or *duan* (*Eruca sativa* L.), *til* (*Sesamum indicum* L.) *niger* (*Guizotia abyssinica* Cass.), jute (*Corchorus capsularis* L. & *C. olitorius* L.) and roselle (*Hibiscus Sabdariffa* L.).

In the case of the leguminous crops studied—san hemp, pigeon pea, Java and Sumatrana indigo—it was found that methods of pure line selection based on the isolation of single plants are not likely to lead to any improvement. In these plants, methods of mass selection, in which crossing is permitted within certain limits, are likely to be considerably more successful.

In Indian linseed, natural crossing was found to be greater than was expected from a study of previous observations and of the mechanism of the flower. In critical work on this crop, it will be necessary to raise all seed under net.

IX. Programme and publications.

Programme, 1919-20. Investigations will be continued on the following crops on the lines indicated in the annual reports and in the publications of the Section—wheat, tobacco, fibre plants, indigo, gram, oil seeds, fodder crops and fruit.

Publications. Thirteen papers were written during the year of which the following have already appeared :—

1. Improvements in the Packing and Transport of Fruit in India. *Bulletin 2, Fruit Experiment Station, Quetta.* Third Edition, 1919.
2. The saving of irrigation water in wheat growing. *Bulletin 4, Fruit Experiment Station, Quetta.* Second Edition, 1919.
3. Report for 1917-18 on Economic Botany for the Board of Scientific Advice.
4. Drainage and crop production in India. *Agricultural Journal of India*, Special Indian Science Congress Number, 1919, p. 377.
5. The agricultural development of Baluchistan. *Bulletin 11, Fruit Experiment Station, Quetta*, 1919.

REPORT OF THE IMPERIAL MYCOLOGIST.

(E. J. Butler, M.B., F.L.S.)

I. Charge and Establishment.

I held charge of the Section until 8th July, when I proceeded to the Federated Malay States on deputation to advise on some matters connected with the local Agricultural Department. Dr. Shaw, Second Imperial Mycologist, officiated for me until my return to India on 14th November. During this period Mr. Dastur, First Assistant, officiated as Second Imperial Mycologist.

I was appointed Joint Director of the Agricultural Research Institute, Pusa, in addition to my own duties, with effect from 20th January. Mr. Dastur was promoted to the Imperial Service and appointed Supernumerary Mycologist on 30th June, 1919.

II. Training.

Mr. M. Mitra, M.Sc., did a short period of research work, as a private student, up to 28th August, 1918, and again joined for a complete course on 27th May, 1919. Pandit S. D. Joshi, B.Sc., a private student, is taking the full course from 12th June, 1919.

III. Mycological Conference.

The second conference of mycological workers in India was held last February, and was constituted, under the orders of the Government of India, as a sectional meeting of the Board of Agriculture. Under these orders, which were issued as a result of the discussions at the Board of Agriculture meeting at Poona in 1917, it is intended to hold similar meetings biennially in those years in which the biennial meetings of the full Board do not take place. The meeting was attended by practically all the mycologists in India and lasted four days. A separate report of the proceedings has been issued.

IV. Diseases of plants.

(1) Ufra of rice. An account of the investigations on this disease carried out since the Bulletin published in 1913 was issued as a Memoir early in 1919. This contains a further study of the life-history and activities of the rice worm, *Tylenchus angustus*; an attempt to explain the anomalies in the behaviour of different classes of cultivated paddies to the disease, which were noticed in the earlier paper but which remained a complete puzzle until the close relation between atmospheric humidity and the movements of the worm on a dry surface was discovered; and finally the application of the facts ascertained to the control of the disease. Further work is in progress or contemplated regarding the factors which influence the motility of the worm and those which influence its persistence under field conditions from one season to the next.

(2) Black Band disease of jute. The research work on this disease was continued by Dr. Shaw during the year under review. The amount of disease in the Bihar jute crop was considerably less in 1918 than in the previous year. This was very possibly due to the earlier termination of the monsoon, and the consequent exceptional dryness during September, resulting in the jute seed crop being harvested a month earlier than in 1917. On the Pusa Farm, while the incidence of the disease was slight in the main area of the crop, one small field was very badly infected. This particular area had been under jute in 1916. Whether the intensity of the disease in a crop is in any way bound up with the length of rotation practised is a factor which must be considered in future field experiments. The fact, mentioned in the last report, that the late sown crop appears to be relatively immune was abundantly confirmed from the inspection of the jute crop all over Bihar. Statistics obtained from the diseased portion of the crop on Pusa Farm showed that it is only stems of a certain size and maturity which are liable to infection under natural conditions in the field. Thus of stems over 5 feet high about 20-25 per cent. were infected with *Diplodia*

Corchori, and the same proportion of diseased plants was observed on counting only stems which were 1 inch or more in thickness at the ground level. In any jute crop, however, there is a considerable number of plants which are the result of late germination and in which the stems remain thin and relatively short. Among stems of this size the disease was practically non-existent, and if such plants are included in the estimation the proportion of diseased stems may be as low as 3 per cent. The proportion of diseased stems among the larger plants, however, gives a more accurate measure of the extent of damage to the crop.

In Eastern Bengal, in August and September, 1918, the fungus was found present in Dacca, Mymensingh, Sinjhani and Haldibari. The number of diseased stems was very small, however, and unless the disease appears earlier it is evidently not likely to be a serious source of damage to the fibre crop. An interesting fact observed was that, in Dacca, red-stemmed varieties of *Corchorus capsularis* seemed to be less susceptible to attack than green-stemmed. On the Rajshahi Farm the crop was *C. olitorius*, both red and green-stemmed varieties, and in this crop also the disease was practically absent. Inoculations now in progress do not, however, support the idea that red-stemmed forms are absolutely immune. A number of artificial infections on the variety "kakya bombai" were carried out in the field, and of inoculations upon wounded stems 90 per cent. proved fatal and upon uninjured stems 50-60 per cent. resulted in the death of the plant. The success or failure of an infection upon an uninjured stem is probably very closely related to the conditions of temperature and humidity at the time and an endeavour will be made to elucidate the relative importance of these factors in the success of an inoculation. Microscopic examination shows that the hyphæ are capable of penetrating the epidermis directly and set up a rapid rot and disintegration in the cortex. This suggests the presence of a cytolytic enzyme, and indeed the fungus has been cultivated successfully on pure cellulose in a solution of inorganic salts.

During the season 1918 a series of field experiments was carried out with the object of throwing some light on the condition affecting the spread of the disease. The results were not so definite as was hoped, the experiments suffering considerably from the abnormal monsoon of 1918, but suggested that the spread of the disease through spores mingled with the seed was not an important means of dissemination. In this case it may not be necessary to persist in the steeping of the Bihar seed crop in a disinfectant. As a precautionary measure, however, the treatment with copper sulphate was carried out this year with some 40 tons of seed grown in Bihar.

While working on the black band disease of jute, a number of cases of disease due to infection with the sclerotial fungus previously identified as *Rhizoctonia Solani* Kühn were met with. It is by no means uncommon in the field for both this fungus and *D. Corchori* Syd. to occur on the same plant, and at first the natural tendency was to assume that all the pycnidia which were so frequently found associated with the sclerotial fungus were immature pycnidia of *D. Corchori*. In 1917 some jute plants were infected with pure cultures of *R. Solani* and all the plants became diseased and died. Upon the diseased portion of the stem small black pycnidia appeared. As these infections were carried out on plants in a field in which *D. Corchori* was rampant, it was thought that we had here a case of a natural infection with *D. Corchori* superimposed upon the artificial inoculation; a brief microscopic examination showing a condition which was considered to be immature *D. Corchori*. In 1918 observations at Dacca showed some cases of disease due to *R. Solani* in which the infection had obviously commenced at a point 2-3 feet above the ground level, and at the time it was by no means plain how a fungus which was only known in a sclerotial form succeeded in establishing itself in this way. Moreover, these specimens and other similar cases in the Pusa crop also showed a pycnidium on the outer surface. These pycnidia and those occurring on the infections of 1917

were now subjected to a more critical examination. The field specimens from Dacca and Pusa both agreed with the infected stems of 1917 in the character of the pycnidium and spores which it contained. While this resembled an immature stage of *D. Corchori* very closely it was obvious that, in the case of the 1917 infections, since they were at the time of this later examination nearly a year old, if the pycnidia were those of *D. Corchori* they should contain mature bicellular spores. In all cases, however, the spores were hyaline, oval and unicellular, and the possibility that this pycnidium was not an immature condition of *D. Corchori* but was a separate fungus, perhaps a stage in the life-history of the sclerotial fungus, had to be investigated. Measurements showed that the spores from the infected stem of 1917 were $16\mu-33\mu \times 5\mu-9\mu$. In the case of specimens collected in the field in Pusa the measurements were $16\mu-25\mu \times 7\mu-9\mu$, and in specimens from Dacca $20\mu-28\mu \times 7\mu-10\mu$. The spores of *Diplodia Corchori* average $24\mu \times 12\mu$, between the limits $20\mu-29\mu \times 10\mu-15\mu$; while therefore the spores of *D. Corchori* are twice as long as broad, those of the new pycnidium are about the same length but narrower. This distinction is not sufficiently marked to enable these spores to be readily distinguished from those of an immature pycnidium of *D. Corchori*, but since the former never become dark coloured or bicellular they can easily be distinguished, provided the age of the infection from which they are taken is known.

The question whether this new pycnidium was a stage in the life-history of the sclerotial fungus, identified in previous communications as *R. Solani*, could only be settled by culture work. Since this work is in progress at the time of writing, it is possible that the conclusions put forward here may be modified in the light of subsequent knowledge. Infections were carried out with a pure culture of the sclerotial fungus, isolated in Dacca, on four jute plants in Pusa. All these plants developed sclerotia and also pycnidia, containing spores measuring $16-24\mu \times 7-9\mu$. Cultures were obtained on agar from single spores and from

single sclerotia, and in both cases produced the sclerotial fungus (*R. Solani*) exactly as the original inoculum. Diseased plants from Dacca were found to carry both *R. Solani* and a pycnidium containing spores $20-28\mu \times 7-10\mu$. Cultures from single spores and single sclerotia from these specimens both gave the sclerotial fungus. The suggestion, therefore, is that the pycnidium is a spore-bearing stage of the sclerotial fungus, and that this pycnidium only occurs on the jute plant, the sterile form occurring in culture.

In April, 1919, a reference was noticed, in a current mycological journal, to a fungus parasitic upon jute in Formosa. The fungus was named *Macrophoma Corchori* Sawada sp. nov., and from the description appeared to be identical with the pycnidium described above. By the courtesy of Professor Kaneyoshi Sawada material of this fungus has been obtained from Japan and examined in Pusa and found to agree with the Indian specimens. Specimens have been sent to Japan in order that a similar comparison may be made there.

(3) **Fruit work in Kumaon.** The root rot of apple and cherry trees due to a species of *Rosellinia* continued to cause a certain amount of loss. Some dead trees have been left standing in the hope that the perfect stage of the fungus will be produced and will enable the species to be identified. This disease was most severe on a section of the orchard which had been recently cleared of jungle and, as mentioned in the last report, is generally worst on the black soils which are rich in humus acids. It also appears to be favoured in situations where drainage is deficient, and extensive drains are projected on one orchard.

The apple cracking and branch blister, which was attributed to the fungus *Coniothecium chomatosporum*, was not so severe. Field observations have raised considerable doubts as to whether this disease in Kumaon is of the same nature as that described in Europe and South Africa under this name. Thus while the cracking of apples occurs on one variety, the branch blisters are present on two other varieties of which the fruit is undamaged. Further work

is necessary before the conclusions of previous authors can be entirely accepted. Spraying experiments with lime sulphur, Berger's lime sulphur and Burgundy mixture failed to check completely the disease. About 5 per cent. of the fruit of a certain variety, on both sprayed and unsprayed trees, was damaged.

Apple mildew (*Podosphæra* sp.) is perhaps the most widespread of the fungal troubles of apple trees in Kumaon. This disease seems to spread rapidly during the month immediately preceding the break of the monsoon. Spraying with lime sulphur during this period was not very efficient in controlling the disease, although in one or two cases, in which, at the risk of damaging the tree, a heavy application of double "summer" strength lime sulphur was applied, the disease was brought under control and infected shoots produced a further growth of healthy leaves. During 1918 mildew was especially severe on one orchard on which during that year no spraying had been carried out. In 1919 the spraying upon this orchard was done with a mixture containing iron sulphide, prepared according to the formula recommended for the Pajaro Valley, and mildew was very much less than in the previous year. Experiments will be carried out during the coming season to test the relative merits of iron sulphide and lime sulphur as sprays against apple mildew. Of the various varieties of apple, "Northern Spy" is the most liable to mildew in Kumaon, and serves as a centre of infection for other varieties. It is being destroyed on one orchard.

Fly speck and sooty blotch (*Leptothyrium Pomi*) is a disease which, while not actually damaging the apple, affects the market value of the fruit owing to the unsightly markings which it causes on the skin. This disease was much less severe on the trees which had been sprayed with lime sulphur than on trees which had not been sprayed at all.

Peach leaf curl (*Exoascus deformans*) had been serious in 1918, and in 1919 certain areas under peach were treated with lime sulphur, Burgundy mixture and Berger's lime

sulphur. All these sprays proved efficacious and there was not a single case of the fungal leaf curl in the sprayed areas. It was very interesting to note that one tree which had escaped the attention of the spraying gang became covered with the leaf curl.

During the progress of the spraying experiments in Kumaon striking differences were noticed both in the susceptibility of different varieties of apple to disease and their liability to spray injury from the different sprays. Future spraying experiments will be largely influenced by the information obtained in this direction.

(4) Chilli diseases. The study of the diseases of chillies has been continued by Mr. Dastur.

Further experiments in the treatment of "die-back" caused by *Vermicularia Capsici* Syd. did not give any definite results. The methods adopted were preventive spraying, shade, and late sowing. There was a failure of the monsoon in September and October, and the consequent dryness of the air, at the time when the normal high humidity and the susceptible stage of growth of the plant usually combine to produce an outbreak, prevented the fungus from developing, and the crop remained free from attack. It was, therefore, impossible to judge of the effect on the disease of the various measures tried. However, it is evident that an attempt to avoid damage from this parasite by sowing a month later than the usual time, so that the susceptible period when flowering occurs may be delayed to the drier period of the cold weather, is not likely to be commercially profitable. The yield of fruits obtained from the late-sown crop was very poor. Similarly the interculture of *rahar* (*Cajanus indicus*) as a shade crop between the rows of chillies had the effect of stunting the latter and cannot be recommended. Further experiments on the same lines are being continued this year.

The blossom and twig rot of chillies, caused by *Choanephora cucurbitarum* (B. & Rav.) Thaxt., which was mentioned in last year's report as having done considerable damage in 1917-18, was not observed last year on a single

plant. This suggests that the disease is dependent on humidity, the chief difference between the two seasons being the abnormal dryness of that under report at the flowering period.

Some damage was done by a new chilli disease, the cause of which is unknown. It starts from the base of the forked branches and is characterized by a dull black discoloration of the green bark which travels up the limbs and down the main branch. The black bark later becomes chalky-white, the appearance being quite distinct from that caused by die-back. On the white portions raised blisters appear and these crack longitudinally. As a rule the injury is confined to those parts of the plant facing south. No organism has as yet been detected associated with the diseased condition. The effect on the plant is to cause the upper parts to shed their leaves and gradually die back.

(5) Pythium disease of ginger, tobacco and papaya. The work on this disease, commenced about three years ago by L. S. Subramaniam, Third Assistant, was completed to a stage justifying publication recently, and an account of it is now in the press as a Memoir.

The parasite was first isolated from tobacco and subsequently from ginger and papaya. In all cases it proved to be the same species and the strains from tobacco and ginger were each found capable of attacking the other two hosts. It has also been found in nature to cause a damping off of chilli seedlings, and artificial inoculations with cultures from tobacco and ginger gave successful infection of chilli, castor and potato. The strain isolated from papaya has hitherto only been tried on the same host, but from its similarity to the others, and the readiness with which these attack the papaya and produce the typical symptoms, it may be expected that the papaya fungus will also attack the other plants mentioned. There is, therefore, so far as the experiments go, no indication that the fungus possesses specialized races.

On tobacco and chilli the attack is a simple damping off, similar to that caused by *Pythium de Baryanum.* Large

number of plants are sometimes destroyed in the seed beds from this cause in the neighbourhood of Pusa. On older plants attack cannot be secured unless the humidity is maintained at a high level, and such humidities are not usually found at any but the early period of the growth of the crop in Bihar. Natural attack on plants subsequent to the seedling stage have not been observed.

On ginger the disease has long been known and its field characters and control were described by Mr. McRae in 1911. It causes a soft rot of the rhizomes and base of the stem in several widely-separated parts of India, and is a disease of much importance to ginger cultivation. As the underground parts are attacked, the disease is found during periods when the soil is moist, and is chiefly confined to the monsoon and early part of the dry weather following. It may thus last almost up to the time when the plants are fully grown.

On papaya the attack usually takes the form of a foot rot of the base of the stem at or just above ground level Sometimes the stem higher up is affected. Large areas of soft rotting develop and the tree is often ultimately blown over. As before, the progress of the disease is usually confined to the rainy season.

The fungus on ginger was formerly identified by the writer as *Pythium gracile* Schenk, but these further studies have led Subramaniam to separate it from that species, and he has named it *P. Butleri* n. sp. It is evidently a wide-spread and, at times, destructive parasite in India.

Definite suggestions for its control have been made, and tested experimentally with good results, by Mr. McRae for ginger and L. S. Subramaniam for papaya. Attempts to check it in tobacco seed beds have proved less successful. Treatment of the soil with the ordinary antiseptics usually recommended has failed, but a treatment by burning dry grass on the surface was effective on a small scale. Further work in this direction is required.

(6) Pigeon pea wilt. Work on this disease was continued by the writer in collaboration with Mr. Finlow,

Fibre Expert to the Government of Bengal. It has been noticed during the last few years that the incidence of wilt in the permanent manurial experiments on the farm varies greatly in the different plots, being less in those that have received no manure and more in those that have had mineral fertilizers. This occurred in both series of the experiments and was too clearly marked to be accidental. Its examination has been taken up in the hope that it may throw some light on the obscure problem of resistance and susceptibility to fungous diseases in plants. The cropping hostory and soil composition of these plots are particularly well known, and they have received uniform treatment for the past eleven years, so that they are very suitable for the purpose.

Two possibilities suggest themselves: either the treatment of the plots has in some way altered the composition or characters of the host plant, or it has influenced the parasite. If the former, it should be possible to correct the deleterious effect of the mineral fertilizers by appropriate manurial treatment, since it is presumably nutritional. For this purpose a second series of permanent manurial experiments has been laid down and artificially infected so as to produce a heavy attack of wilt in all the plots in the first year. If the condition depends on some effect of the mineral fertilizers on the parasite (which is a soil fungus), it should be possible to detect this by regarding the soil as a culture medium and examining its effects on the vigour or virulence of the fungus. For this purpose pot cultures with soil from the permanent plots have been started and have already given some interesting results. Attempts have also been made, hitherto without success, to determine quantitatively the amount of the parasite in the soils of the different plots, and it is proposed to test the effect of the soil solution on the growth of the fungus. Mr. Finlow has meanwhile carried out a complete ash analysis of the plant from several of the plots. The root development under different manurial treatments is also being examined. It is not expected that definite results will be obtained before several years.

(7) Sugarcane smut. Mr. Dastur has investigated the mode of infection of the sugarcane smut, *Ustilago Sacchari* Rabenh. It has been found that direct infection of thin varieties of cane can take place only in two ways: (1) through the young tender "eyes" and (2) through the older "eyes" when they are wounded or injured. Thick cane varieties can only be infected in the latter manner, and this is evidently one of the causes of their relative immunity to smut. The infection has not been found to take place through the cut ends of setts or through adventitious roots. The hyphæ enter the "eyes" through the unthickened scale hairs, and have not been observed to penetrate the epidermal cells directly. Inoculated plants have given smutted shoots in two months, while setts cut from canes, the dormant eyes of which were infected in the autumn, gave rise to smutted stools when sown the following spring. This explains why setts taken from stools which show no external signs of the disease can, when planted, give a smutted crop. Further work is in progress but the results already obtained mark a decided advance in our knowledge of the ætiology of this important disease.

(8) Rangoon bean. The disease of the Rangoon bean (*Phaseolus lunatus*) originally erroneously reported in the press as due to *Phytophthora* was investigated by Dr. Shaw during the past year. The attention of the Department of Agriculture, Burma, was first drawn to this disease by a European planter engaged in agriculture in the Kyaukse District. It is not improbable that the disease is of long standing as even now Burmese cultivators are reluctant to report its presence and may have had it for years without the local agricultural authorities knowing of it. The recent increase in the area under Rangoon bean ("pebyugale") and the method of cultivation which is practised, may have increased the amount of the disease, but there is no means of judging of the extent of the trouble prior to the first report.

The increase in the area under Rangoon bean, consequent upon the rise in price of this commodity during the war, led to the crop being grown in situations in which it

would not otherwise have been laid down. In particular, mango gardens were cultivated with "pebyugale" under the trees, and in such shaded situations the disease seems worse.

The method of cultivation takes no account of the habit of *Phaseolus lunatus*. This plant is a climber. It is, however, hardly ever grown as such, but the seed is broadcasted on the field and the plant is left to form a straggling growth. The result of this, and of the heavy sowing rate, is to form a dense mat of vegetation, about 18″ or more thick, all over the field. Within this light and air cannot penetrate and humidity is very high. The conditions within such a mat of vegetation are ideal for the development of any fungus, and particularly for a fungus which makes its most active growth at relatively low temperatures as does the present parasite.

In a publication of the Burma Department of Agriculture (Leaflet No. 47) it is recommended that the crop be sown in lines $2\frac{1}{2}$ feet apart. Where this advice has been followed, little or no disease can be seen and the yield of beans is actually improved, as where the plants are widely spaced a far greater number of flowers are borne and come to maturity.

The fungus possesses large black sclerotia with a septate mycelium bearing a conidial stage in the genus *Botrytis*. Upon damp sand or moist corn meal the sclerotia will germinate and produce long stalk-like structures. So far these stalk-like structures have failed to produce any fructification. During the forthcoming cold season infections will be carried out on a number of different species of *Phaseolus*.

(9) Other diseases. The rotting of stored potatoes is a serious problem in several parts of India, both as affecting potatoes stored for seed and as restricting the supply intended for consumption. Dr. Shaw visited Poona in November to see the potato storing system worked out by the Bombay Department of Agriculture in co-operation with a private firm, and to advise on the methods adopted.

Some 900 tons of potatoes intended for Mesopotamia had been dealt with in this manner very successfully. A field-man has been placed in charge of experiments carried out during the present hot weather in the Punjab. The whole subject was discussed at length at the mycological meeting in February, and the directions in which further work is desirable were brought out. It seems probable that progress will be difficult unless some method can be devised of storing the tubers at a lower temperature than that to which they are habitually exposed in the areas concerned.

Rust in wheat was first observed in Pusa on 23rd December, when a few plants were found infected with *Puccinia triticina.* By the middle of January there were plants with uredo sori scattered throughout the crop. The last week of January was cloudy and 1½ inch of rain fell on the 30th and 31st. This led to a moderately severe outbreak of orange rust, which brought out the varying susceptibility of the varieties on the farm to a marked degree, some being almost free from attack while the ground under others was brown from the shed spores. *Puccinia graminis* was first observed early in March and did relatively little damage. *Puccinia glumarum* was not seen at all, a most unusual circumstance at Pusa. The Australian Federation wheat proved highly resistant to both rusts, while Mundi of Jullundar, Makhai of Chiniot, Pusa 4 and Cawnpore 13 were highly resistant to orange rust.

Dr. Shaw's work on sclerotial fungi was continued. The two diseases of sugarcane from the Central Provinces, referred to in a previous annual report, appear to be identical with the diseases known as Het Zuur Rot and Het Rood Rot in Java. The latter form, or one very closely resembling it, has also been collected upon jute (*Corchorus olitorius*) at Rajshahi, Bengal.

Field experiments with the "tokra" (*Orobanche*) parasitic upon tobacco were continued. A crop of tobacco from seed of *Nicotiana rustica*, obtained from Peshawar, was grown in an infected field. In Peshawar District tobacco

is not infected with *Orobanche*, and it was thought that possibly seed from this locality might give an immune crop. Such, however, was not the case as the crop grown from Peshawar seed was just as badly diseased from *Orobanche* as the crop from local seed in the same field.

A comparative study of the species of *Helminthosporium* found on cultivated cereals and sugarcane at Pusa has been commenced. Practically every cereal grown here is attacked by one or more of these fungi, but it is already probable that some of them are common to several hosts and that the total number of species is not large. The work includes morphological study based on cultures as well as inoculation work to determine the range of host plants of each species.

Some work on a *Sclerospora* found on *Andropogon annulatus* in 1918 was carried out, with a view to getting a clue to the method by which the allied cereal downy mildews are transmitted. This is entirely unknown. No results have, however, as yet been obtained.

Comparative studies of some species of *Phytophthora* have given results of interest. The American species *Ph. terrestria* Sherbakoff has been found to agree with the earlier described Indian *Ph. parasitica* by Mr. Dastur. Recently both this and another species have been discovered attacking coconuts in Jamaica, and the latter has been found to be one of the causes of bud rot in the West Indies. Cultures sent to the writer have proved to be identical with his *Ph. palmivora* first described under the name *Pythium palmivorum* in Memoirs, Dept. of Agric. India, Bot. Ser., Vol. I, No. 5, p. 82, 1907. It is evident that one form at least of this most destructive West Indian disease is caused by the same organism which has been so fully studied in India, and an old controversy is thus settled in a manner satisfactory to us. Some work has also been done on the species of this genus found on rubber, and has strengthened the view held in this laboratory that the forms hitherto found on this host in India and Burma are all belonging to the one species.

V. Miscellaneous.

During the mycological meeting in February, the greatest interest was aroused by the demonstration of fungi parasitic on man and the higher animals by Captain Froilano de Mello, Director of Bacteriological Services, Goa. Captain de Mello worked in the laboratory for about a fortnight with material brought from Goa as well as some obtained locally, and was able to give a detailed demonstration of the technique required for the isolation and cultivation of these fungi.

Mr. S. N. Bal, Assistant Professor of Botany, Science College, Calcutta University, spent about a fortnight in the laboratory in March and April, as he proposes to take up mycological work in Calcutta. Mr. J. C. Nag, Senior Professor of Botany, Presidency College, Calcutta, also visited us with the same object in view, in June. Economic mycologists in India will welcome the increasing tendency towards the study of the subject in other than its economic bearings in Indian Universities, as there is a great field as yet but little explored in this direction. Large collections of named fungi were given to Mr. Bal, Mr. Nag, the Central Hindu College (Benares), St. Xavier's College (Bombay), Baroda College and the Government College, Lahore. Some Indian *Loranthaceæ* were also sent to Professor Weir in the United States, cultures of *Phytophthora* to various enquirers and some fungi parasitic on scale insects to the Government Mycologist, Ceylon.

During the year a development of great importance for the co-ordination of mycological work in the Empire took place. Proposals by the Imperial War Conference for the formation of an Imperial Bureau of Mycology to be situated in London were accepted, and the Government of India have agreed to subscribe £250 annually for three years in the first instance towards its cost. The lines on which such a Bureau could be of most use to mycologists in India were discussed at the meeting of Indian mycologists in February,

and a detailed note on the subject was submitted by the meeting to the proper authorities.

The writer has commenced the preparation of a systematic list of the fungi of India, as the references are at present so scattered that it is almost impossible to get a general view of the composition of the fungus flora of the country.

VI. Programme of work for 1919-20.

(1) *Research work.* New diseases of Indian crops that come to the notice of the Section will be investigated as opportunity permits, but the following diseases will receive special attention and will constitute main lines of investigation :—

(*a*) Ufra of paddy.
(*b*) Black band of jute.
(*c*) Chilli diseases.
(*d*) Fusarium wilts, especially in relation to soil and manurial conditions.
(*e*) Sclerotial diseases of jute, sugarcane, paddy and Rangoon bean.
(*f*) Orchard diseases.

Minor investigations will include the study of some fruit anthracnoses, *Orobanche* on tobacco, root rot of cotton, sugarcane smut, sal root rot and *Pythium* disease of papaya, ginger and tobacco.

(2) *Systematic work.* It is hoped to resume this with the facilities provided by the proposed Imperial Bureau of Mycology in London. Steps will be taken to supply the Bureau with representative collections from India. The preparation of a list of Indian fungi will be continued

(3) *Training.* This will be continued on the lines indicated in the prospectus.

(4) *Routine work.* Advice and assistance will be given to Provincial Departments of Agriculture and other departments and to the general public.

VII. Publications.

Butler, E. J. . . The Rice worm (*Tylenchus angustus*) and its control. *Mem. Dept. of Agric. India, Bot. Ser.*, Vol. X, No. 1.

Shaw, F. J. F. . . Report on Mycology, 1917-18, for the Board of Scientific Advice.

REPORT OF THE IMPERIAL ENTOMOLOGIST.

(T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S.)

I. Administration.

The Imperial Entomologist held charge of the Section throughout the year ended 30th June, 1919, except for a period of one month from 9th September, 1918, when he was on privilege leave. The post of Supernumerary Entomologist, which had remained vacant for four years, was filled by Mr. M. Afzal Husain, M.Sc., who joined the Department on 6th January, 1919. Mr. Y. Ramachandra Rao, M.A., Entomological Assistant in Madras, was on deputation during the year to work under the Imperial Entomologist on an investigation of the insects which occur on *Lantana* in India and Burma; his period of deputation was completed on 31st March, 1919, after which he returned to Madras, and has since submitted a report on his investigations, which has been sent in for publication.

II. Training.

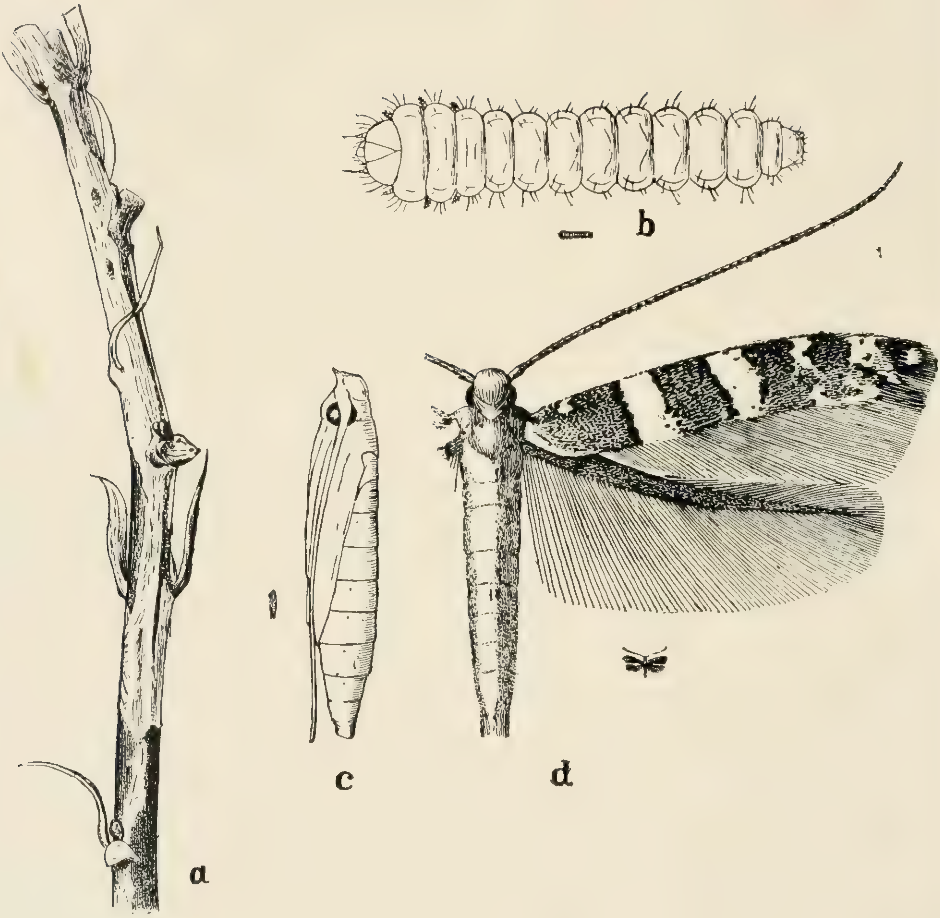
One student, Mr. G. D. Austin, deputed by the Ceylon Department of Agriculture, was received on 1st June for a course in Economic Entomology.

Mr. H. S. Pruthi, B.Sc., a student of the Government College at Lahore, was also received towards the end of the year and is working on the anatomy of *Dysdereus cingulatus*.

Four students completed a short course of instruction in sericulture and two in lac-culture.

III. Insect Pests.

A summarized account of our knowledge of Indian Crop-pests was given in a lengthy paper by the present writer read at the Third Entomological Meeting held at Pusa in February, 1919, and this information was supple-



Acrocercops sp.

a, Cotton branch attacked by larva.
b, Larva, dorsal view, natural size and magnified.
c, Pupa, natural size and magnified.
d, Moth, natural size and magnified.

mented by other papers, read at the same Meeting, on pests of cotton, fruit-trees, borers in sugarcane and cereals, etc. To these papers the following observations may be regarded as supplementary.

Cotton. The question of determining the relative immunity of the varieties of cotton was continued throughout the year, and it was found that certain varieties appear to enjoy a partial though not a complete immunity from bollworm attack. Work on these lines has been considerably hampered by the infestation of the cotton plants with *Pseudococcus corymbatus* and *Phenacoccus hirsutus* and later with *Eriophyes* sp. (probably *E. gossypii*). The unusual appearance of *Ps. corymbatus* was traced to a plot of soy bean closely adjacent to the cotton plots. The life-history of this Coccid has been worked out, together with those of its parasites and predators.

Hibiscus abelmoschus has continued to be a good trap-crop for bollworms, a larger number of parasitized bollworms being found in the shoots and pods of this plant than in either cotton or *H. esculentus*. As in the previous year the number of Pink Bollworms (*Platyedra gossypiella*) was found to exceed that of the Bollworms (*Earias* sp.) from October onwards.

Observations were made on a Bethylid (? *Parasierola* sp.) found in affected cotton-bolls containing larvæ of *P. gossypiella*. Another Bethylid has also been obtained from infected material received from Cawnpore.

In the search for alternative foodplants of *P. gossypiella* a large number of pods of *Thespesia populnea* was examined without result, but these pods were found to contain Phycitid larvæ boring in them.

A short note on cotton bollworms was read at the Third Entomological Meeting.

A Gracillariad (*Acrocercops* sp.) larva was observed to mine under the bark of cotton at Pusa (Plate VII). It is an extensive borer and causes a layer of bark to peel off the entire stem and even from the leaf stalks. This insect has not been noted on cotton previously.

Rice. Work on the borer pests of rice has been continued. By continued observation of the crop throughout the year and by actual counts it has been ascertained that the percentage of damage (about 29 per cent. on the average) given in last year's Report was exaggerated, due to the fact that this figure was arrived at by examination of the stubble only. Actually the damage done in the vicinity of Pusa does not seem to exceed about 4 per cent., but this cannot be taken as a normal figure for the more important rice-growing districts of India. The presence of unusually large numbers of the three principal borers in the stubble (*viz.*, *Schœnobius bipunctifer*, *Sesamia inferens* and *Chilo*) is due to the large pre-winter broods which, however, are not capable of doing much damage to the ripening crop.

A new external agent of damage has been discovered in the form of a Chrysomelid (Halticine) grub which bores into the stems of rice and millet seedlings from outside and causes a regular dead-heart. This insect has occurred in some numbers and ranks as a pest.

Sugarcane. Work on the borer pests of sugarcane and other gramineous plants was continued (1) to ascertain the effect of treatment of attacked canes by the cutting out of "dead-hearts," (2) to ascertain the species of borers in cultivated as well as in wild grasses, (3) to discriminate the various species hitherto confused under the name of *Chilo simplex* ("moth-borer"), (4) to find out the alternative foodplants of these various borers, (5) to trace out their seasonal life-histories and habits, and (6) to study other insects which are not actual borers but which affect the crop, especially the young sugarcane crop, in such a way as to produce effects similar to those caused by the actual borers; as these other insects occur along with the borers, their study is necessary in order to allocate the damage done to the actual agents.

As noted above, the preliminary results attained have been incorporated in a paper, by the present writer and C. C. Ghosh, read at the Third Entomological Meeting,

and it is therefore only necessary to give here a brief summary together with additional facts elicited since the preparation of the paper referred to.

Our experience, under conditions at Pusa, is that the treatment of borers by means of cutting out of "dead-hearts" is of no avail in sugarcane, especially in the case of the young crop, which is best left to grow undisturbed. Treatment by removal of "dead-hearts" seems distinctly injurious to the young crop by interfering with proper tillering. The borers which occur at Pusa (with the exception of *Scirpophaga xanthogastrella* which bores in the top-shoots) do comparatively little damage to the grown canes.

Reckoning all the dipterous maggots as one, since it has not yet been found possible to discriminate the different species of dipterous borers, over thirty different insects have so far been discovered to bore in sugarcane, rice, maize, *juar* (*A. Sorghum*), the smaller millets, and the various wild species of *Saccharum.* Of these, eleven occur in sugarcane, seven in rice, six in maize and *juar*, and four in the smaller millets. The borers in the wild species of *Saccharum* must be looked upon as potential enemies of the cultivated grasses also.

Up to the present, twelve different species have been discriminated amongst those previously lumped together as *Chilo simplex* ("moth-borer"). A key to the larval and pupal stages of some of these was given in last year's Report and a more complete key has been given in the paper referred to above. It need only be noted here, therefore, that the form referred to in last year's Report as ? *Chilo* sp. in rice (C. S. 1768) has since been found to be identical with the ? *Diatræa* sp. in sugarcane at Dacca (C. S. 1674; t. 7, ff. 1, 2), and that *Diatræa* sp. (C. S. 1610), found in sugarcane at Dacca and Pabna, has since been named *Argyria tumidicostalis* by Sir George Hampson.

The alternative foodplants of the various species have been given in the paper referred to. A new alternative foodplant, *viz.*, *Saccharum fuscum*, of *Scirpophaga xantho-*

gastrella has since been discovered; this is in addition to sugarcane, *Saccharum spontaneum* and *S. arundinaceum*.

The search for alternative foodplants has been continued as it has been observed in the case of several borers that the presence or absence of alternative foodplants influences to a great extent the prevalence of these borers in cultivated grasses. It seems possible that, by the use of these alternative wild foodplants, the prevalence of at least some of the borers may be reduced considerably in cultivated crops, but considerable further investigation along these lines is necessary.

The complete seasonal life-histories of twenty species of these borers has been traced out and incorporated in the paper referred to.

With regard to the external agents of damage, some further work has been done to attempt to find out what leads to the prevalence of termites in certain soils. Analyses of infested and non-infested soils have been made by the kindness of the Imperial Agricultural Chemist but further comparisons are required before anything more can be said on this subject.

In April 1919, three species of Dynastine beetles, *viz.*, *Alissonotum impressicolle*, *A. piceum* and *Heteronychus sublævis*, caused serious damage to sugarcane on the Kamrup Farm in Assam. Mr. C. C. Ghosh was sent to investigate the outbreak and ascertained that the beetles were breeding in large numbers amongst the roots of the various kinds of wild grasses growing over miles and miles of the waste land in the midst of which the Farm is situated, and apparently they occur there every year without doing noticeable damage to the cane crop. This year, on account of drought, the emergence of the beetles was deferred until rain fell in March, when an unusually large number of beetles occurred and attacked the crop, especially those portions of it where the germination had been retarded by the drought. *Heteronychus sacchari* has been recorded as damaging sugarcane but this is the first record in our experience of such extensive damage by adult beetles.

Observations have been made on the parasitization of *Aleurolobus barodensis*, an Aleyrodid destructive to sugarcane. It was found that the percentage of parasitization was highest at the end of November, 1918, when it varied between 80 and 95 per cent. For a few days the maximum was as high as 98 per cent. and thereafter the numbers of host and parasite rapidly declined.

A note on "Some Indian Economic Aleyrodidæ." comprising the species destructive to sugarcane, was prepared and read by Mr. C. S Misra at the Third Entomological Meeting.

Indigo. Investigations regarding the parasitization of the Indigo Psylla (*Arytaina isitis*) were continued throughout the year. Three species of Chalcididæ were concerned and of these one was very prominent. The parasitization was found to be highest at the end of May and September; after the latter date it declined gradually until the minimum was reached in February.

Mulberry. The disease known as "Tukra" or "Kokra" referred to in last year's Report, has been definitely ascertained to be caused by a mealy-bug, *Phenacoccus hirsutus*, Green, which is found on the plants together with *Pseudococcus virgatus*, Ckll. The nymphs as well as the adult females congregate on the shoots of the stems and cause the malformation which is so often seen in infested mulberry plantations. Not only is the growth of the plants retarded, but the lower lateral leaves become wilted and drop off. The affected apical leaves, if served to mulberry silkworms, cause "*flacherie*." Ten generations of *Phenacoccus hirsutus* were reared during the year and its parasites and predators were also studied, together with its means of dispersal as well as the best method of treatment of affected plots. Besides mulberry, this scale insect has also been found to occur on cotton, guava fruits, grape vines and fruits, and *Tecoma grandiflora*. Three species of Chalcididæ, as well as *Spalgis epius*, *Eublemma quadrilineata* and a Cecidomyiad fly, check this scale to a great extent. The presence of this mealy-bug is easily

known by the presence of ants (*Monomorium indicum*) which attend the scale-insects for the sake of their honey-dew.

A short account of the "Tukra" disease was prepared and read by Mr. C. S. Misra at the Third Entomological Meeting.

Fruit Pests. Special attention was paid during the year to the collection of information regarding fruit-pests. An Index to Indian Fruit Pests, summarizing the information to date under each plant attacked, was prepared and read by Mr. C. S. Misra at the Third Entomological Meeting, and the information under the various insects was also included in the Annotated List of Indian Crop-pests prepared by the present writer for the same Meeting. The information under this head has, therefore, been written up already, but the following short notes on new pests may be of interest.

Alcides mali, Mshll. MS. (Curculionidæ), was found at Shillong, the larva boring shoots of apple and causing a gall-like swelling. The adult weevil makes several, usually four, holes with its snout in a row in a tender shoot of apple and in one of these holes, and only in one, it deposits an egg. The larvæ tunnel in the stem, which becomes swollen in consequence. Pupation takes place in the larval tunnel. Control is practised by collecting the adult beetles as they rest on the twigs and by cutting off the twigs which show the punctures or the swelling caused by the enclosed larva.

Aclees cribratus, Gyl. (Curculionidæ), was found at Shillong in June-July 1918, the larva boring into the main stem of fig (*Ficus carica*) and doing considerable damage. The adult beetles occur on the stems by day and may be collected by hand although they readily drop to the ground when disturbed.

Deiradognathus (n. g., Curculionidæ, Mshll. MS.) n. sp., was found at Shillong in June-July 1918, the adults occurring on mulberry, apple, pear and fruit trees

generally, nibbling holes in the leaves and doing considerable damage, being present in very large numbers.

Dyscerus malignus, Mshll. MS. (Curculionidæ), was found at Shillong in June 1918. It is brownish-black with a conspicuous grey patch on the posterior portions of the elytra. The adult weevils feed on apple fruits, eating small punctures into them, and oviposit in small excavations along the edge of such patches. The eggs are large for the size of the insect, about 1·25 mm. in diameter, and are pearl-white in colour. The grub bores about in the interior of the fruit and damages it considerably. Pupation takes place inside the attacked fruits, which in the initial stages of attack are externally scarcely distinguishable from healthy fruits, but the invariable presence of a number of small whitish dots on the surface of the infested fruits marks these as attacked. These small dots are really holes through which the tunnels of the grubs communicate with the open air, and as a rule these tunnels originate at the apical end of the fruit, somewhere near the flower-scar, whence they ramify throughout the interior, branches being given off at intervals towards the surface where their termination is marked by the small dots mentioned above. In the later stages of attack, these holes become much larger and often exude a frothy liquid which attracts Sarcophagid flies.

This weevil was also found breeding in the fruits of *Prunus nepalensis*, a wild indigenous plum whose fruits are edible when ripe.

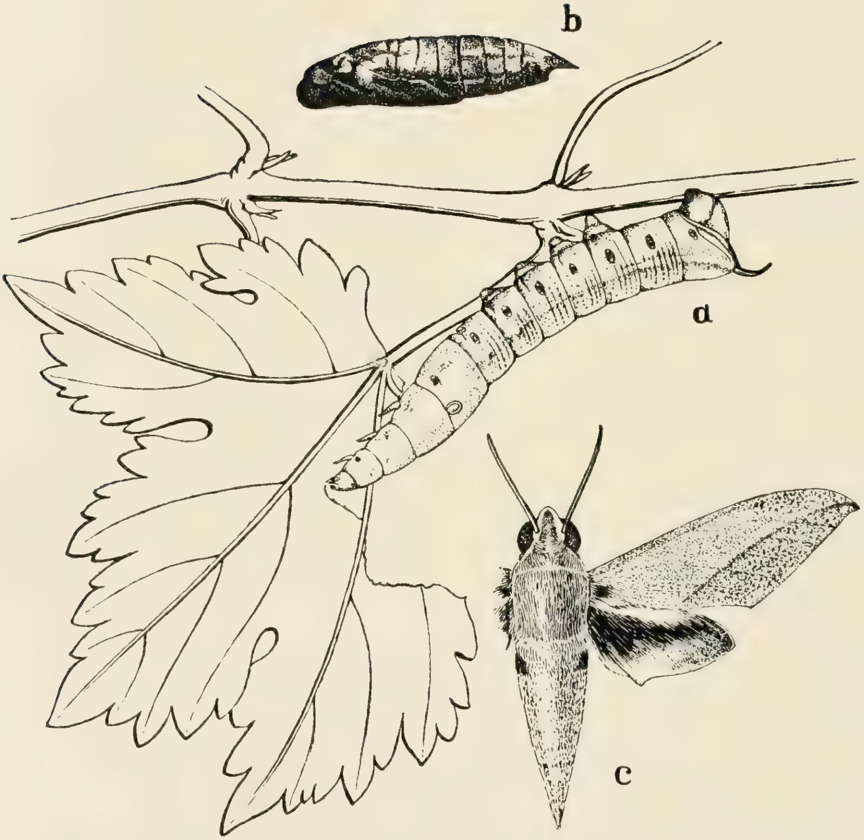
Dyscerus fletcheri, Mshll. MS., was also found at Shillong, the larva boring in apple fruits. The adult weevil is a reddish-brown species with scattered patches of greyish scales. It is rather larger than *D. malignus* but attacks apple fruits in exactly the same way, but pupation seems to take place sometimes outside of the fruit. The egg is about 1 mm. in diameter and rather dull-brown in colour. The larva seems quite similar to that of *D. malignus*. The adults appear to be long-lived, as an

individual caught in Shillong about 15th June and brought to Pusa, lived in the Insectary until 15th October.

Linda nigroscutata, Fairm. (Lamiadæ), was found at Shillong where the adults occur fairly commonly on apple trees in June and July, and were generally found resting on the shoots or leaves and occasionally feeding on the latter. In captivity the beetles fed on the leaves and also on the bark of apple twigs, but did not oviposit. Under natural conditions, however, the beetle girdles the twig more or less (usually rather less) completely, makes a slit at right angles to the girdling and above it, slightly detaches the bark on one side of this slit and thrusts in an egg under this loosened bark. The larva on hatching bores upwards into the twig and thrusts its longish pellets of frass out through holes cut in the twig, which of course dies off and shrivels up. This is a serious pest, doing considerable damage. The only control method possible is hand-collection of the beetles and cutting out of attacked twigs. No alternative foodplant is known as yet.

Chelidonium cinctum, Guer. (Cerambycidæ), was sent in from Bangalore by Mr. R. D. Anstead who found the larva boring into orange branches. The eggs are deposited in June in the axils of young living twigs and never on dead wood or old branches. The young larva bores into the twig and works upwards for a distance of about half-an-inch to an inch-and-a-half and then makes two tiny holes about the size of a pin's head; it then turns back and bores down the twig, occasionally making small openings; finally it gets into the main branches where it makes tunnels a quarter of an inch in diameter. The young twigs that are bored at once die and turn black, so that they are conspicuous and can be cut off with the larva inside them. By doing this and by hand-collection of the adults the attack can be controlled to a large extent.

Oxyambulyx sericeipennis, Butl. (Sphingidæ), occurred in some numbers at Shillong in July 1918 on walnut, each larva defoliating considerably, so that the damage may be fairly large in the case of young trees.



Theretra gnoma.

a, Larva, feeding on grape-vine leaf, natural size.
b, Pupa, natural size.
c, Moth, natural size.

Theretra gnoma, Fb. (Sphingidæ), occurred on grape-vine at Pusa (Plate VIII). This is a regular feeder on grape-vine and is a minor pest at times. It has also been reared at Pusa and Poona on leaves of "elephant's foot."

An undetermined Sphingid was found at Shillong as a serious pest of apple, and to a less extent of pear, about the end of June. It does considerable damage, as the larvæ are not easy to see in spite of their large size, and one larva will strip a whole branch of leaves. Pupation probably takes place under dead leaves in natural conditions. There is only one brood annually, the pupa hibernating. We have also had this insect sent in as infesting apple in Kulu. The moth has not yet been bred, but is probably *Langia zenzeroides.*

Actias selene, Hb. (Saturniadæ), occurs as a pest of apple in the Khasi Hills and Kumaon. It feeds on various other plants and has been found on pear and walnut, as well as on *Betula alnoides*, *Odina wodier*, etc.

Antheræa roylei (Saturniadæ) was also found attacking apple and pear at Shillong.

Heterographis bengalella, Rag. (Pyralidæ), occurs at Pusa every year as a minor pest of custard-apple, the larvæ tunnelling in the fruits. It appears to be common throughout Bengal.

Meridarchis reprobata, Meyr. (Carposinidæ) was sent in from Kashmir as boring and damaging cultivated olives. The larva feeds in the Plains in the fruits of *Eugenia jambolana.*

An unidentified Eucosmid larva was found boring apple fruits at Ramgarh (Kumaon) in much the same way as the notorious Codling Moth (*Laspeyresia pomonella*), from which, however, the Indian species seems to be distinct. The moth has not yet been reared out. This is likely to prove an important pest if it attains access to other apple-growing districts.

Acrocercops hierocosma, Meyr. ? (Gracillariadæ), occurred in numbers in litchi fruits at Pusa in May 1919.

A. hierocosma has been reared at Pusa in September and October from larvæ mining leaves of *N. litchi.* Only one moth could be reared from the larvæ in the fruits and this is slightly different from the leaf-mining form, although it is probably the same species. This fruit-infesting larva is referred to in *Indian Museum Notes*, Vol. V, pp. 121-122, t. 15, ff. 4, 4*a*, where it is unnamed.

Life-histories of Insects. Besides the various insects mentioned above, a large number of insects has been reared during the year and observations made on life-histories and habits. In a Report of this nature it is only possible to mention a few of these even by name.

(1) *Monohammus versteegi.* Eggs of this longicorn beetle borer in orange stems were collected in June 1918 at Haflong in North Cachar. The adult has been reared out and found to have one generation annually.

(2) Grubs of a longicorn beetle borer in jak stems (Plate IX, fig. 1.) were collected in Sylhet in June 1918. These are still (July 1919) feeding and will probably live another year, so that the larval stage extends over a period of two or three years in this case.

(3) *Cryptorrhynchus gravis.* This serious pest of mango fruits in Eastern Bengal and Assam was formerly supposed to lay its eggs in the flowers. This year it was definitely ascertained that the eggs are laid, not in the flowers, but in the fruits, even well-grown ripening fruits not being immune. The period of oviposition is an extended one. The shortest period for completion of the life-cycle is about three weeks or even less. Local observations and experiments extending over a whole year are necessary for the suggestion of preventive or remedial measures.

(4) *Balaninus c-album.* Short details of the life-history of this weevil infesting *Eugenia jambolana* fruits were given in last year's Report. A quantity of infested seed was kept buried at a depth of about two feet; no weevil succeeded in emerging from these seeds. Collection and adequate burial of the seeds should therefore keep this weevil in check.

EXPLANATION OF PLATE IX.

Fig. 1. Longicorn beetle borer in jak stems

a, Section of jak stem, showing larval tunnel.
b, Full-grown larva, natural size.
c, Beetle, natural size.

Fig. 2. Cecidomyiad on mango leaf.

a, Mango leaf, showing galls.
b, Adult fly, natural size and magnified.

PLATE IX.

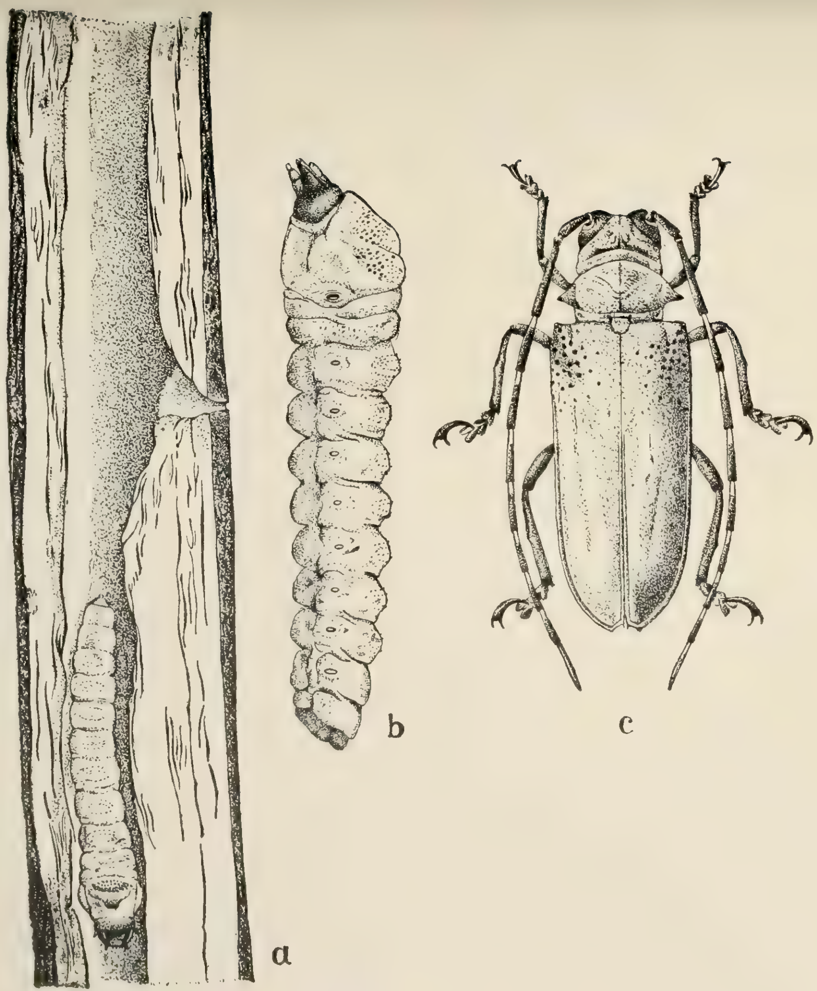


Fig. 1. Longicorn beetle borer in jak stems.

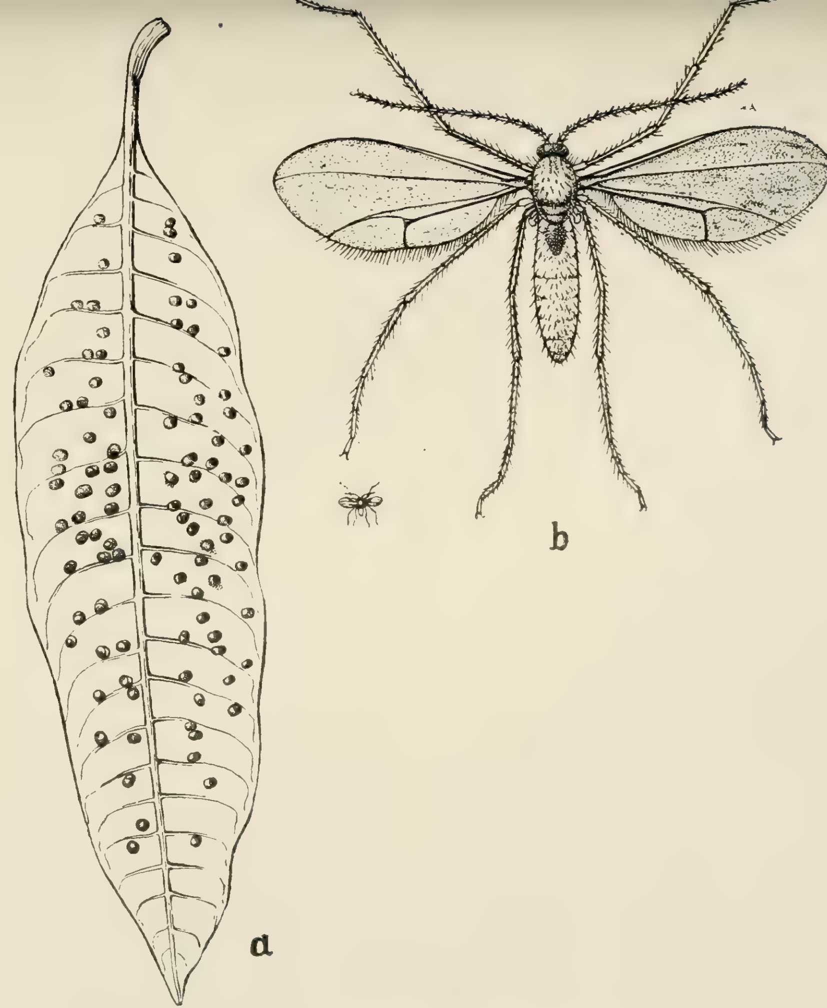


Fig. 2. Cecidomyiad on mango leaf.

(5) *Virachola isocrates* was found in small numbers in May 1919 infesting peach fruits at Pusa. This butterfly does not seem to have been recorded previously as attacking peach.

(6) *Earias fabia* and *E. insulana* have been found in fair numbers in the flower-buds of *Hibiscus rosa-sinensis.*

(7) *Heliothis peltigera* occurred in fair numbers in the larval state on leaves of *Carthamus tinctorius.* It is probable that this insect will prove to be a specific pest of safflower, but it has hitherto been overlooked and confused with *H. obsoleta.*

(8) *Platyedra gossypiella.* A sample of Cambodia cotton brought from Coimbatore showed that about 28 per cent. of the seeds had been bored by the caterpillars of this insect.

Grain Storage Experiments. These experiments were concluded and the results written up in a paper read at the Third Entomological Meeting and in which full instructions have been given regarding the methods to be adopted for storing cereals, pulses, etc., in order to keep them free from insects in the store-house.

Protection of wood against Termites. The results so far obtained have been embodied in a paper read at the Third Entomological Meeting. The work is being continued.

Lantana work. This work was taken up in November 1916 on instructions from Government, and has had for its object the collection of information regarding the occurrence within the Indian Empire of any insects which may be utilized as efficient checks on the growth of *Lantana.* With this object Mr. Y. Ramachandra Rao, M.A., Entomological Assistant in Madras, was placed on special deputation under the Imperial Entomologist, and during the year under report worked in Assam, the Punjab, the United Provinces, Bihar, the Central Provinces and Madras. His period of deputation expired on 31st March, 1919, when he returned to Madras. A complete report on his work has been submitted for publication as a Memoir.

IV. Bees, Lac and Silk.

Bees. The work with the local variety of the Indian Bee (*Apis indica*) has been continued. There have been numerous inquiries on this subject during the year from residents in all parts of India. Improved hives have been prepared locally and supplied to various correspondents. Two show-cases, illustrative of bee-keeping, were prepared and supplied to the Agricultural Association, Muzaffarpur.

A Bengali Bulletin on Bee-keeping was published during the year and the first edition has already been nearly sold out.

A paper on "Bee-keeping in India" was read by Mr. C. C. Ghosh at the Third Entomological Meeting.

Lac. The emergence of lac larvæ took place at Pusa on 14th October, 1918, and 20th June, 1919. A small quantity of ber (*Zizyphus jujuba*) brood-lac was obtained from Malda, Bengal, to place on the trees. The October crop was fairly good but the June crop was poor, having been adversely affected by the unusually hot weather during May.

Two students were trained in lac-culture, and brood-lac was supplied to various applicants.

A note on lac-culture was prepared and read by Mr. C. S. Misra at the Third Entomological Meeting, and in April Mr. Misra attended the Meeting of the Board of Forestry where the question of developing the Lac Industry in India was discussed.

Silk. The Sericultural establishment is still on a temporary footing which has been extended up to 31st March, 1920. In the meantime work is being continued with the twenty multivoltine mongrel races of mulberry silkworms which have been established by crossing univoltine and multivoltine races. In these mongrel crosses it has been noticed that the yield of silk from the first generation of crosses is always better than that in later generations, which seem to deteriorate gradually. Attempts are being made to prevent this deterioration by the infusion of new blood in the mongrel races. We appear to have succeeded

in establishing a race which, on crossing with univoltine races, changes the resultant mongrel races into multivoltines in five or six generations, so that any univoltine races can be made multivoltine in a comparatively short time. Eggs of univoltine Chinese, Japanese, French and Bengali races and of a Japanese bivoltine race were sent for cold storage to Guindy, Shillong and Muktesar, and were successfully reared at Pusa in October and March.

Mulberry silkworm eggs have been supplied to Indore, Gwalior, Mysore, Banganapalle, Travancore, Mahlog (Simla), North-West Frontier Province, Northern Shan States, Nagano Sericultural College (Japan), to the different Salvation Army silk centres and to about 110 other applicants in all parts of India. Eri silkworm eggs have been supplied to Egypt, British East Africa and Japan and to about 75 applicants in India. Castor seeds and mulberry seeds and cuttings were also distributed to about 19 applicants. One Pusa reeling machine was supplied to the Agricultural Department, New South Wales, and another to Indore State. Silk exhibits were sent to various agricultural exhibitions and commercial museums. One rearer and one reeler were sent to the Saunders Weaving School at Amarapura (Burma), and one rearer and one mulberry gardener were sent to the Northern Shan States to start sericulture there. Many inquiries regarding rearing, reeling, dyeing, bleaching, spinning and twisting have been dealt with, and silk samples and bulletins on sericulture have been distributed to numerous correspondents. Silk pieces and castor seeds to the value of Rs. 2,071-3-4 were sold and the proceeds credited to Government, silk pieces to the value of Rs. 2,023-9-0 having been woven during the year.

Four students, two from Bihar and two from Bengal, completed short courses in sericulture during the year.

V. Illustrations.

Coloured plates illustrating the life-histories of the following insects were prepared during the year, *viz.*,

Laphygma exigua, *Oxyambulyx sericeipennis*, *Langia zenzeroides*, *Alcides mali*, *Brahmæa wallichii* and a sawfly attacking rose. Besides these, over four hundred illustrations in black and white were prepared in the course of the year and many of these have been sent in for publication in illustration of various papers read at the Third Entomological Meeting.

Considerable difficulty has been experienced in connection with the preparation of coloured lantern-slides of insect-pests, for which there is a considerable demand on the part of the Provincial Agricultural Departments. Towards the close of the year some sample slides, prepared by a new process, were obtained and, if these prove satisfactory, it is hoped that demands may be met.

VI. Miscellaneous.

Correspondence. A total of 74 parcels of specimens, mostly of crop-pests, was received during the year for identification and advice, whilst 805 letters were received and 1,083 issued; these numbers show a slight decrease on previous years but are exclusive of a large amount of routine correspondence which takes up a considerable proportion of time which should be devoted to more scientific work.

VII. Insect Survey.

Steady progress has been made in additions to, and arrangement and identification of, the collection which is now a large and important one and continues to expand at a rapid rate. In view of the great value of this collection, both from an economic and systematic point of view, to future students of Indian Entomology, every effort is made for the proper preservation of the large mass of specimens, a task which is by no means easy in a climate such as that of Pusa. The more irreplaceable portions of the collection and those liable to most damage are therefore being placed in cabinets which are being obtained as rapidly as possible. The staff required for the upkeep (which includes the sorting and identification, as well as

the mere preservation, of the many thousands of specimens already accumulated and received every year) has not been increased since a time, many years ago, when the collection was comparatively quite small; yet this work is constantly expanding and has already become very heavy, although this is only one branch of the activities of the Entomological Section.

The war interfered considerably with the transmission of specimens for identification and later on the work entailed by the Entomological Meeting left little time for the sending out of specimens, but the following collections have been sent out to Specialists in the groups named and our thanks are due to them for the ready help afforded :—

(*i*) Microlepidoptera to Mr. E. Meyrick, F.R.S. Named and returned. The descriptions of numerous novelties are published in *Exotic Microlepidoptera.*

(*ii*) Diptera to Mr. E. Brunetti. Mostly named and returned.

(*iii*) Carabidæ to Mr. H. E. Andrews. Returned named.

(*iv*) Odonata to Major F. C. Fraser. Returned named.

(*v*) Stephanidæ to Mr. Elliott.

(*vi*) Ichneumonidæ to Mr. C. Morley.

(*vii*) Tenthredinidæ to Mr. Rohwer.

(*viii*) Bees to Professor T. D. A. Cockerell.

(*ix*) Dipteron parasitic on cotton mealy-bugs to Dr. L. O. Howard, Washington. Returned named as *Gitonides perspicax.*

(*x*) Tetriginæ to Dr. J. L. Hancock, Chicago.

(*xi*) Staphylinidæ to Dr. M. Cameron.

(*xii*) Curculionidæ to Dr. G. A. K. Marshall. Returned named.

(*xiii*) Scolytidæ to Mr. C. Beeson.

The following collections, sent out in previous years, have not yet been returned :—

(*xiv*) Histeridæ to Mr. G. Lewis.

(*xv*) Longicorn beetles to Dr. Gahan.

(*xvi*) Anthribidæ to Dr. K. Jordan.
(*xvii*) Rhynchota to Mr. W. L. Distant.
(*xviii*) Tetriginæ to Dr. J. L. Hancock.
(*xix*) Cicindelidæ to Mr. S. W. Kemp.
(*xx*) Aquatic Rhynchota to Mr. C. A. Paiva.
(*xxi*) Bruchidæ to Dr. G. A. K. Marshall.
(*xxii*) Hispinæ and Cassidinæ to Professor S. Maulik.

Various collections of Indian insects have been received and named and returned as far as possible. These included collections sent by the Forest Research Institute, the Provincial Agricultural Departments and by numerous correspondents.

VIII. Third Entomological Meeting.

The Third Entomological Meeting was held at Pusa from 3rd to 15th February, 1919, and was well attended by delegates and visitors from India, Ceylon and Egypt. Over ninety subjects, mostly dealt with in written papers, were laid before the Meeting which may be said to have been highly successful. A short account was written for the April (1919) Number of the "Agricultural Journal of India," and a full Report of the Proceedings has been submitted for publication, so that it seems unnecessary to say more here except to affirm that such Meetings are of very real value and interest to all concerned in the study of Indian insects.

IX. Programme of work for 1919-20.

Major.

This will follow generally on the lines of work of the current year and will include general investigations of crop-pests and especially of the pests of sugarcane, rice and cotton, of fruit-trees, and of stored grain.

Minor.

Results in various lines of work require to be written up and published as far as possible. Work and experiments in silk, lac and bee-keeping will be continued and

new insecticides and insecticidal methods tested as occasion arises. Systematic work on Indian insects will be carried out with our own resources and the help of specialist correspondents. Advice and assistance will be given as far as possible to Provincial Departments and to all inquirers on entomological subjects.

X. Publications.

The following publications, either written by the Pusa staff or based on material sent from Pusa, have been actually issued during the year :—

Dutt, G. R. .	Descriptions of three male Mutillids from India. (*Rec. Ind. Mus.*, XVI, 259-261.)
Fletcher, T. Bainbrigge.	Agricultural Entomology. (*Annual Report, Board Sci. Advice for India,* 1917-18.)
Fletcher, T. Bainbrigge.	The Third Entomological Meeting. (*Agric. Journ. of India,* April 1919.)
Fraser, F. C. . .	The hitherto undescribed female of the dragonfly, *Hemicordulia asiatica.* (*Journ. Bombay Nat. Hist. Soc.,* XXVI, 488.)
Ghosh, C. C. . .	Bengali Bulletin on Bee-keeping.
Meyrick, E. . .	Exotic Microlepidoptera, Vol. II, Parts 6-7.

REPORT OF THE IMPERIAL PATHOLOGICAL ENTOMOLOGIST.

(F. M. Howlett.)

I was in charge of the Section for the year, except for an absence on privilege leave from 9th to 23rd December, 1918, when Mr. Patel was in charge.

For practically the entire period, however, I was on special duty, in connection, firstly, with the prevention of surra-transmission by Tabanidæ, more particularly among transport camels, and, secondly, with the improvement of existing culicifuges for military use. Reports on the work done in these two directions have been separately submitted.

Little has been done outside these special enquiries, but Mr. Patel, besides continuing his work on midges and completing the manuscript of a book on cattle-flies, has studied the parasites of some animals and birds likely to be associated with human beings, and has made several new discoveries, including a blood-sucking muscoid larva with habits comparable to those of the notorious "Congo floor-maggot." Messrs. Sen and Sharma have continued, when circumstances permitted, the physiological work on mosquitos referred to in the programme for the year.

In January I attended the Science Congress in Bombay; in March the Veterinary Conference at Lahore; in April and May meetings of the Drugs Committee at Simla and the Surra Research Committee at Delhi.

The following papers were read at the sixth session of the Indian Science Congress held at Bombay:—

"Post-war Zoology" (Presidential Address to Zoological Section). F. M. Howlett.

"Tactics against Insects" (Evening lecture). F. M. Howlett.

"Life-history of a midge, *Culicoides oxystoma*, with some remarks on the early stages of *Ceratopogon*." P. G. Patel.

"The effect of mercurous chloride on the larvæ of *Culicidæ*." S. K. Sen.

"A preliminary note on the action of acids, salts and alkalies on the development of Culicid eggs and larvæ." H. N. Sharma.

Programme of work for 1919-20.

It is anticipated that the special enquiry on culicifuges may be continued, but orders have not yet been received. With this reservation, the main heads under which work will be carried on are as defined in last year's programme.

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST.

(C. M. Hutchinson, B.A.)

I. Administration.

I was in charge of the Section during the year except for one month's privilege leave during September, 1918.

Captain J. H. Walton, Supernumerary Agricultural Bacteriologist, returned from military duty in Mesopotamia and Palestine after an absence of about four years.

II. Training.

Mr. K. Adinarayan Rao, a student from Mysore State, is under training in agricultural bacteriology, from 12th June, 1918.

Mr. H. S. Govinda Rao, a student deputed by the Mysore Government, to undergo training in laboratory technique in connection with silkworm diseases, worked in this Section from 17th December, 1918, to 26th June, 1919.

III. Soil Biology.

Nitrification. Field and plot observations of seasonal variation in nitrification in soils under crop and fallow were maintained; the results obtained confirmed the opinion that movement of soil water either upward or downward conduces to increased formation of nitrates; such movement may be caused by drainage, by surface evaporation, or by plant absorption (transpiration), this last factor accounting for the greater total nitrification found in cropped as compared with fallow plots. An important point affected by soil management seems to be the annual re-establishment of nitrifying flora to take the place of that eliminated by adverse conditions, such as waterlogging, during the monsoon; the success of this operation depends upon

recognition of the fact that nitrifying bacteria can perform their specific function under conditions adverse to their multiplication; such conditions include not only the presence of specific toxins but of excess of organic matter or of ammonia; the immediate oxygen requirements of the nitrifiers are generally satisfied in almost any soil but water-logging during the monsoon not only conduces to the development of toxin-producing bacteria but to the bringing into solution of excessive amounts of organic matter, all of which tend to depress the nitrifying flora as an indirect effect of anaerobic conditions. The addition of inert material of large superficial area such as broken brick or clinker appears to provide a suitable nidus for the development of nitrifying bacteria, not so much in the soil as on the surface of the broken material, thus setting up conditions similar to that in a sewage filter, where solutions containing concentrations of organic matter too high to allow of development of nitrifying flora are nevertheless nitrified by the organisms previously established on the broken surfaces. It is of interest to note that in experiments dealing with the addition of broken brick and potsherds to soil it is necessary to make allowance for the frequently high content of nitrate, generally as saltpetre, found in such materials in Bihar.

A considerable amount of work was done by the First Assistant on the different rates of nitrification of various organic materials in soil. These included various green manures and other plants, and oilcakes, and it was found that the non-nitrogenous portion had an inhibiting action upon the nitrification of the nitrogenous fractions. A paper on this subject was read by the First Assistant at the Indian Science Congress, Bombay (January, 1919).

Further experiments on the inhibition of nitrification by toxins resulting from anaerobic incubation of soils were carried out; it was found that nitrification did not begin for ten weeks in Omelianski solution made up with water extract of anaerobically incubated soil, whereas nitrification was complete in eight weeks in a similar solution but

from an aerobically incubated soil. Similar results were obtained when using pure cultures of nitrite formers seeded into these media.

The effect of excessive quantities of nitrogenous matter in inhibiting nitrification was tested in various soils; in Pusa soil 60 mgm. N per 100 gm. soil was found to be the maximum amount allowing complete and normal nitrification, either as ammonium sulphate or oilcake; when applied as a mixture of these two, however, it is possible to raise the combined amount to 90 mgm. without prejudicing the nitrification either by loss of ammonia or by delay. It is of interest to note that nitrification can take place even in a soil in which there is sufficient free ammonia to be detected by smell and litmus reaction.

Green-manuring. The green-manuring experiments carried out in collaboration with the Imperial Agriculturist on the Punjab experimental plots were continued. These experiments begin to show the valuable residual effect of such treatment on Pusa soils especially with fermented green manure (*Crotalaria juncea*). Incidentally most valuable and interesting light has been thrown upon the interpretation of the results of field experiments on such soils and in such a climate; the results obtained show clearly first of all the necessity of previously ascertaining the relative fertility of the plots before treatment and the absolute worthlessness of most manurial experiments without this precaution, and, secondly, the equal necessity of taking into account the effect of seasonal variation from one year to another. These points as illustrated by the green-manuring experiments referred to, are discussed in an article on this subject in the "Agricultural Journal of India" now in hand.

Biological analysis of soils. Further work was done on this subject and the question of the use of a standardized method was discussed at the Conference of Agricultural Chemists and Bacteriologists at Pusa in February. A special study was made of certain infertile soils (Manat) from the Konkan Division (Bombay). The First Assistant

visited this district and inspected the soils in the field and having carried out biological analyses in the laboratory a report with recommendations for treatment was written and submitted to the Director of Agriculture, Bombay.

Nitrogen fixation. The question of the nitrogen supply in Indian soils and exhaustion by the introduction of intensive cultivation and heavy-yielding varieties of crops was dealt with in a paper by me read at the Indian Science Congress in Bombay. In this paper attention was drawn to the danger of encouraging methods of exhausting Indian soils without making any adequate provision for keeping up the supply of the ingredients removed by increased crop yields; the loss of nitrogen especially must be guarded against when this takes place at a rate exceeding that of the natural fixation by legumes and non-symbiotic soil organisms. In this connection it was pointed out at the Conference of Chemists and Bacteriologists at Pusa in February, 1919, that special attention should be paid to the study of the conditions under which nitrogen fixation takes place in Indian soils, with a view to determining the possibility or otherwise of artificially obtaining optimum conditions for such fixation as a practical field measure. The very great variations in the amount of nitrogen fixed in the same soil in different years show clearly the possibility of influencing fixation by soil management without the necessity of adding impossibly expensive materials (such as sugar) to the soil. In the Punjab, nitrogen to the extent of 30 per cent. of that already present in a soil under single crop wheat, was fixed in less than six months in one season, whereas during the following one the amount was negligible. The possible symbiotic relationship between green algæ and nitrogen-fixing organisms in soils formed a subject for investigation at Pusa by the Supernumerary Bacteriologist before the war as a continuation of his study of azotobacter in India and has now been resumed on his return from military service.

Further work on fixation of nitrogen by legumes was carried out and a memoir embodying the results was written

by the First Assistant. It was found that in cases, where nodule formation did not occur owing to the use of strains of the *radicicola* organism foreign to the plant, the latter nevertheless benefited by the supply of nitrogen a-symbioti-cally fixed in the soil to which such organisms had been added artificially. Similar results were obtained with azotobacter inoculation and by the growth of legume bacteria in artificial media separated from the soil containing the growing plant by porous cylinders. An interesting and important point was noticed, namely, that in the case of *B. radicicola* no residual nitrogen was found in the culture sand suggesting that fixation of nitrogen proceeded *pari passu* with its removal by the growing plant, whereas with azotobacter this was not the case. A modified medium (soil extract—mannite,—asparagin agar) was found to allow ready isolation of the organisms direct from soil.

IV. Indigo.

The isolation of considerable quantities of pure indican in the laboratory of the Indigo Research Chemist permitted the use of synthetic media for the cultivation of the various strains of indican hydrolyzing bacteria already isolated in the Bacteriological Section during two previous seasons on agar made up with indigo leaf extract. It was found that very little growth or hydrolysis took place in media in which indican was the only source of nitrogen, whereas the addition of small quantities of leaf extract activated this at once. Study of the physiological aspects of this question is being carried on.

Manufacture. Further experiments were carried out in the experimental factory on the hot water extraction method. Very good results were obtained by the use of lime precipitation following extraction and preceding ino-culation with hydrolyzing bacteria; the improvement not only included higher percentage extraction of the indican present in the plant, but greater purity in the product. Experiments were initiated in the use of hypochlorite steri-

lization of the water and plant as an alternative to hot water extraction; this would be a very much cheaper method of eliminating undesirable bacterial flora than the use of hot water, but it is not yet clear whether it will be possible to obtain the high percentage extraction of indican given by the latter process.

A point of great practical interest arose during the first days of manufacture. It was found that owing to the "weathering" of the cement-lining surfaces of the vats during the months intervening between one manufacturing season and the next following one, lime was set free by disintegration in sufficient quantity to produce an alkaline reaction in the steeping water of such a degree as to interfere seriously with the growth and activity of the hydrolyzing bacteria; in this way fermentation was delayed to such an extent that even after twelve hours this process then normally complete was only just beginning. It was found necessary to add considerable quantities of acid (250 c.c. of 50 per cent. sulphuric acid per 600 gallons) to neutralize this alkalinity. There can be no doubt that a similar action takes place in all factories using cement-walled vats, and that the "warming up" of the vats commonly noticed at the beginning of each season is due partly to the removal of the disintegrated lime from the walls as well as to the gradual establishment of the necessary bacterial flora.

It is of interest to note here that numerous reports have been received from indigo factories of improved yields resulting from the use of cross walls or other methods of increasing the wall area of the vats, recommended (1917-18) as a result of the discovery of the importance of bacterial action in the fermentation of the indigo plant.

V. Pebrine.

Further study of the problem of elimination of this disease of the silkworm in India, included trial of the effect of hill-rearing upon the natural resistance of the larva to

infection. Experiments were carried out at Shillong during August and September; layings of eggs from Pusa were divided, half being reared at Pusa and half at Shillong; artificial infection was carried out at both places and it was found that even in the first generation a considerable increase in resistance to infection was obtained in the hill-reared larvæ. Eggs from the latter were transferred to Pusa both from infected and from disease-free moths, and further resistance to infection in the plains was noted in the latter, whilst in the former a smaller percentage of infected larvæ resulted from the hatching out of seed from the diseased moths; the infected larvæ also survived through a greater number of moults and a larger percentage of them attained maturity than is usual in such cases. It was also noted that the hill-reared worms produced better cocoons. It is proposed to continue this line of experiment and to recommend the institution of a central seed station at Shillong to provide ameliorated seed for the Indian industry. The revised method of examination of moths previously reported has been adopted by various grainages in India; the Sericultural Superintendent at Berhampore (Bengal) has reported favourably on his experience of its use during the last season. It is abundantly clear that owing to the use of multivoltine races in India and the generally insanitary conditions under which rearing is carried out it is essential for the rearer to begin his season with disease-free seed, in default of which the rapid cumulative effect of any small percentage of disease initially present, in the course of rearing the numerous broods characteristic of the multivoltine races, will inevitably result in the failure of a fatally large proportion of the worms. For this reason it is necessary to adopt in India a much higher standard of purity in the seed issued by grainages than is customary in Europe. A lecture on this subject was given at the Entomological Conference held at Pusa in February, 1919. A memoir on the mechanism of infection and the elimination of pebrine in India is now in the press.

VI. Sterilization of water.

Attention was drawn to this subject owing to the outbreak of a severe cholera epidemic in the neighbourhood of Pusa, and the difficulty of obtaining antiseptics. Attempts were made to obtain a stable hypochlorite solution by electrolytic methods and the work was transferred to Shillong whilst I was on hill recess there; owing to the kindness of the Director of the Pasteur Institute who allowed me to work in his laboratoy and the courtesy of the officers of the Local Government who allowed me to make use of the electric current supply of Government House, I was able to continue this investigation and was also fortunate enough to secure the assistance of Captain W. Hodgkinson, R.E., who was put on deputation by the Army Department for this purpose and has since been working on this problem at Pusa. It has been found possible to produce a solution containing from 3-4 per cent. available chlorine by electrolysis from purely Indian raw materials, thus avoiding the use of imported bleaching powder and having the consequent advantage of avoiding the great loss of chlorine in transit and in store incidental to the use of " bleach; " at the same time this solution (now known as E. C.) can be prepared anywhere where electric current is available, and can be made of standard strength merely by reading figures on an ordinary current meter without expert knowledge either of chemical or electrical methods. This work was done at the instance of the Stores Department of the Indian Medical Service with the object of providing a reliable method of sterilizing water for troops on field service or elsewhere; the principal difficulty encountered has been to obtain a sufficient degree of stability to allow of storage for such periods of time as may be necessary for transport to situations where electric current is unavailable; the degree of stability possessed by E. C., like that of all hypochlorite solutions, varies inversely with the temperature of storage, but owing to the method of preparation and the use of an appropriate stabilizer it should be sufficient to ensure its efficiency under most conditions

likely to be encountered. Further work is now being done to ascertain the most efficient form of apparatus for production of this solution on a practical scale.

VII. Programme of work for 1919-20.

Major subject.

1. Nitrogen fixation in Indian soils.

Special enquiries.

2. Indigo manufacture.
3. Pebrine disease of silkworms.
4. Sterilization of water.

Minor subjects.

5. Bacterial diseases of plants.
6. Biological analysis of soils.

VIII. Publications

Hutchinson, C. M. . Report on Agricultural Bacteriology, 1917-18, for the Board of Scientific Advice.

Hutchinson, C. M. . Nitrogen Fixation in Indian Soils. *Agric. Journ. of India*, XIV, 2.

Hutchinson, C. M. . Nitrogenous Fertilizers: Their use in India. *Agric. Journ. of India*, XIV, 2.

Joshi, N. V. . . . Rate of Nitrification of different Green Manures and parts of Green Manures and the influence of crop residues on nitrification. *Agric. Journ. of India*, Special Indian Science Congress Number, 1919.

REPORT OF THE IMPERIAL COTTON SPECIALIST.

(G. A. Gammie, F.L.S.)

I. Charge.

I was in charge of the post throughout the year.

II. Cottons in the Provinces.

Bombay Presidency.

Khandesh. On the Jalgaon Farm, in East Khandesh, experiments have been continued to test the actual values of some of the inferior components of the local mixture, and of the Sindewahi Cross which was developed in the Central Provinces.

The local N. R. (Khandesh *neglectum roseum*) is declared to be good for spinning 10's. Poona N. R. and the local N. R. C. have no staple and, although the proportion of lint to seed is high, neither is worth any encouragement and they should be thrown out.

The cotton of the Sindewahi Cross is reported to be near *berar-oomra.* It is silky, of good staple, though rather variable, and it can spin 16's.

The money value per acre works out as follows:—N. R. C., Rs. 72-7-0; N. R., Rs. 69-10-0; and Sindewahi Cross, Rs. 62-12-0. These figures prove that, if cottons of better staple are desired by the trade from Khandesh, it must be prepared to pay a premium to compensate for the smaller yield to the cultivator who otherwise will continue to grow the cotton which gives him the greater profit. I would emphasize the necessity of maintaining on the Jalgaon Farm tests with the more valuable yellow-flowered forms of *neglectums* which do possess something in the nature of a staple.

Samples from five localities on the Nizam's Hyderabad-Godavery Valley Railway were grown for comparison on this farm. Messrs. Tata Sons & Co. carefully examined

the cottons grown from these samples and reported as follows :—" We have examined these five samples and all seem to have greatly improved on the Jalgaon Farm. We would strongly recommend the cultivation of *moglai* cotton seeds in the Khandesh tract. The samples have all obtained the characteristics of *moglai* cotton which is considered to be of good staple. That from Dharmabad comes first; from Purna, second; from Nander, third; from Parbhani, fourth; and Jalna, fifth. This judgment confirms the opinion that we expressed some years ago that a steady increase in quality occurs from Jalna onwards to Dharmabad.

" In Nander, there is such a great mixture of varieties of cotton that only a small number of bales of pure good long-stapled Nander is available.

" This year the rates of *moglai* cotton, such as Nander, etc., are about Rs. 70 lower than *broach* rates, but ordinarily they used to be very nearly equal or about Rs. 10 lower. All these samples are good for spinning 16's to 20's."

The value per *candy* (784 lb.) of these samples ran from Rs. 460 to Rs. 480, while those of the selections of N. R. cotton on the Jalgaon Farm ranged from Rs. 390 to Rs. 400, the value of *fine khandesh* cotton standing on the same day at Rs. 445. We have, however, no information regarding the acreage values of these *moglai* cottons.

We have arranged for the testing of yellow-flowered types of the local crop and the Sindewahi Cross against the inferior white-flowered types in alternate strips of moderate size, and these trials will have to be repeated for several seasons.

Southern Maratha Country. The type of cotton generally cultivated in Sholapur is the *jari* mixture of *neglectums* prevailing in Khandesh and Berar; in this mixture there are stray plants of *herbaceum* (*jowari hatti*) and Upland. The neighbouring tracts of the Nizam's Dominions produce a very high class of cotton from a type, in which *bani* predominates, known as " *karkheli*." Before it is finally decided to introduce N. R. into this tract to the

exclusion of every other variety it will be advisable for the local department to give an exhaustive trial to the *karkheli* of the Nizam's territory which has a ginning percentage of 29-30, and to the yellow-flowered types of the local cotton including the Sindewahi Cross from the Central Provinces. All forms of *kumpta* are tested on the Dharwar Farm, and all Uplands at the Gadag Farm which enjoys the advantages of both the south-west and north-east monsoons, a condition essential for their proper cultivation.

On the Dharwar Farm, the following selections of *kumpta* have been under test for several years, and as regards merit they stand in the following order :—

Kumpta Selection (Dharwar I), an erect type, with short branches, chosen not only for the quality of its lint but also for its habit of growth, comes first, with an acreage return of Rs. 153-2-0, a ginning percentage of 29·1 and the value of lint Rs. 640, the ordinary *kumpta* with a ginning percentage of 25·2 being quoted at Rs. 625.

Kumpta Selection (Dharwar II), a bushy type, the prevailing one in the fields. The branches are longer than in the first. Its acreage outturn is Rs. 130-2-0, the ginning percentage is 29·3, and the lint is valued at Rs. 630 per *candy*.

When these selections were first made it was expected that the more compact growth of Dharwar I would allow of closer planting and therefore a higher yield, and this has been confirmed by the experience of several years. But the possibility of there being a difference in the lint also was never suspected, and this has been emphasized by means of reports from Messrs. Tata Sons & Co., who say that Dharwar I is decidedly superior in length of staple, while the cotton of Dharwar II is bulky and resembles more in appearance to what is called *Pivatney* (Foot-roll). *Kumpta ordinary*, cultivators' *kumpta*, gathered for the purpose of comparison was valued at Rs. 625. It has a ginning percentage of 25·2 and a lint value of Rs. 625. All the above samples were considered fit for spinning 24's to 30's.

At the Gadag Farm, experiments are conducted with different forms of Upland cottons known as Dharwar-American which, as has been stated, require both monsoons. Their cultivation is naturally restricted to the tracts where these climatic conditions prevail. They exist in the fields mixed with *jowari hatti* (*kumpta*) round Ranibennur. This mixture of Dharwar-American and *kumpta* cannot be treated as fraudulent, but must be taken as a precautionary measure on the part of the cultivators to ensure a crop from at least one variety. In a normal year the Dharwar-American ripens first and the crop is mostly off the land before the *kumpta* comes in so that both can be marketed at different times. The local department ought to work out the actual economic significance of this mixed cropping. The doubtful variety is Dharwar-American, as *kumpta* is more generally grown pure.

In 1912-1913, I pointed out that the deterioration of the Dharwar-American cotton had been caused by the mixture of Upland and New Orleans types of cotton, and arranged with the Director of Agriculture for the testing of the same. As a result of this test the Upland type has proved far more promising in outturn, ginning percentage, and the quality of fibre than the New Orleans type. The Upland type, on an average, gives 60 lb. more *kapas* per acre than the ordinary Dharwar-American mixture, gins 3 per cent. higher, and in value commands Rs. 15 more per *candy* of 784 lb. The following statement gives the average outturn and ginning percentage of the three types, which will be found to be of interest :—

Name of variety	Average outturn per acre for 6 years	Average ginning percentage
	lb.	
Dharwar-American (ordinary) . .	400	29·0
Upland type	467	32·0
New Orleans type	386	29·5

Samples from the Gadag Farm were arranged in the following order :—

Dharwar-American, Upland type selection, gave an acreage return of Rs. 142, a ginning percentage of 36, and a value of Rs. 640. The quotation for saw-ginned cotton on the day was Rs. 615. A sample of ordinary Dharwar-American gathered for comparison gave an acreage return of Rs. 92-8, a ginning percentage of 31·4 and a value of Rs. 620 per *candy*.

Dharwar-American, New Orleans type, gave an acreage return of Rs. 88-6-0, a ginning percentage of 32, and was valued at Rs. 630.

All these cottons are good for spinning 20's to 30's.

In order to ascertain whether the qualities of fibre, ginning percentage, etc., have any direct connection with the condition of the soil, a number of soil samples from representative tracts were taken and samples of cotton were also taken from the same lands.

The soil samples were submitted to Dr. Leather who made the following remarks after their examination :—

"The soils may be divided into two groups from the chemical standpoint, namely, those containing high proportions of carbonate of lime which are from the villages Bhilavadi, Miraj, Sangli and Bijapur, and the remainder which contain very much less. The former contain not only a high proportion of carbonate of lime but also a very low percentage of available phosphate and available potash. The other group consists of the remainder, namely, soils from villages Pachhapur, Dharwar, Huilgol and Halgali. All these soils contain, comparatively speaking, low proportions of carbonate of lime but rather more available phosphate and potash; at the same time, although the proportion of carbonate of lime in the soil from these four villages is low for black cotton soil, it is sufficient for ordinary agricultural needs.

"You will see that the chemical analysis does not divide the soils exactly as the physical analysis did, though one

can see the same classification on looking over both the elutriation and percolation tests figures. The soils from Bhilavadi, Sangli and Bijapur are physically imperfect and are in need of phosphatic manuring; the soil from village Miraj may not be physically imperfect, but it does require phosphatic manuring. Of the other group, soils from Pachhapur and Halgali villages seem to me to be likely to dry up very quickly but are from the chemical standpoint better off than the others. The soils from Dharwar and Huilgol villages although chemically and probably geologically the same as those from Pachhapur and Halgali, are physically different, especially that from Dharwar. I shall be very interested to hear from you what the agricultural differences are. I would certainly have thought that the soils from villages Bhilavadi and Sangli were agriculturally different from Miraj soil, although they are chemically so very similar; and in the same way I would have expected Pachhapur and Halgali soils to be agriculturally different from that of Dharwar, although here again chemically they are so similar."

As regards the classification of the soils by Dr. Leather, it will be seen that he divides them into two sections. The valuations of the cotton samples from the same fields prove that they arrange themselves almost exactly in the same order. Thus in Section I, Bhilavadi cotton was valued at Rs. 272, Miraj at Rs. 280, Sangli at Rs. 285, and Bijapur at Rs. 265; and in Section II, Pachhapur at Rs. 300, Dharwar at Rs. 280, Huilgol-Gadag at Rs. 290, and Halgali (Ranibennur) at Rs. 270. The rate of *ordinary kumpta* for the day was Rs. 275.

Gujarat. At Surat, attention is concentrated on the difficult problem of how to improve the *surat deshi* cotton which is very homogenous in character and is already the best of the indigenous cottons. Three strains have been isolated and studied: (1) 1027 ALF, (2) Selection IA, and (3) Selection II. For the first period of five years, the ginning percentages were: (1) 36·7, (2) 36·0 and (3) 35·7, respectively, and for the second period of the last three

years, they were (1) 34·5, (2) 36·6 and (3) 35·6. The ginning percentages of *surat deshi* for the same periods were 33·3 and 32·7. On this point alone it will be conceded that the cultivator gains in quantity by using one of the selections instead of his *surat deshi.* As regards the actual improvement of a selection, it will be useful to record the progress of 1027 ALF for the last 8 years. In 1912-13, it was reported to have acquired the characters of *surat* cotton with a slightly short staple; in 1913-14 it was considered almost equal to *navsari* in length and feel; in 1914-15 it was in no way inferior to *navsari*, long, silky, and strong; in 1915-16 the same remarks were made; in 1916-17 it was considered superior to *navsari;* in 1917-18 the same remark was made; and in 1918-19 it was reported as good, long-stapled, silky cotton and almost equal to Middling American. As regards production, the cotton of 1027 ALF was valued at Rs. 206-10-0 per acre, that of Selection IA at Rs. 192-12-0, that of Selection II at Rs. 155, and of the local *surat deshi* at Rs. 136.

For the current season the local department has distributed, in separate groups of villages, sufficient seed of Selection IA and Selection II to cover 5,000 acres, and a special staff has been retained to supervise all operations on these from sowing till the sale of their produce in the market.

For several years past the staple of *broach deshi* has steadily gone from bad to worse on account of the introduction of an inferior type of cotton known as *ghogari.* An experimental station was started in Broach to test the characters of *ghogari* as a pure crop, as its origin, history and nature were unknown. It has proved to be a prolific cropper of a grade of cotton resembling *bengals,* with a high ginning percentage. A number of forms were isolated and tested and none were found to approach *broach* in any way. The only alternative that suggests itself is that *broach* itself should be rigorously tested to see whether some form of it could not be developed to give a better profit than *ghogari.* The experiments at Ajupura have shown that

there is a possibility of this. If it can be proved that the cultivator loses nothing by abandoning *ghogari*, the authorities will be justified in prohibiting its cultivation. Messrs. Tata & Sons had the following remarks to offer on some samples of *ghogari* taken from the Broach Farm :—

"They have no staple at all (except one which seems to have a little) and they resemble *bengals* more than any other variety. We are given to understand that this type has not only taken a firm hold in the *broach* cotton tract but it has also extended into the Surat District. If this is the fact, it is greatly to be regretted, since it is not at all desirable that such a short-stapled type should be encouraged in Broach and Surat Districts. We would therefore strongly recommend that the department should take rigid steps to discourage the growth of such types in Broach and Surat."

I think that the possibility of identity between *wagad* and *ghogari* should be investigated by a local interchange of seeds, *viz.*, by testing *ghogari* (under proper restrictions) somewhere near Viramgaum and *wagad* at Jambusar. I am also of opinion that, at Dohad Farm in the Panch Mahals, experiments should be confined to the testing of *herbaceum* cottons of whose tract this area is a natural extension, and that it is not desirable to allow *neglectum* cottons a footing in a staple cotton tract.

At Ajupura, in the Kaira District, Selection IA from Surat, yielded 472 lb. of seed cotton (value Rs. 131 per acre) with a ginning percentage of 37·2, *wagad* gave 456 lb. (value Rs. 131) with a ginning percentage of 36·8, *ghogari* gave 411 lb. (value Rs. 117) with a ginning percentage of 36·8, and the local *kanvi* gave 398 lb. (value Rs. 114) with a ginning percentage of 38.

Central India.

Samples of four cottons were received from the Indore Farm for valuation and remarks. They stood in the following order :—

(1) *Cambodia*. Value per acre Rs. 137-7-0, outturn 710 lb. seed cotton, ginning percentage 33,

valuation Rs. 460 per *candy*. This was sown under irrigation in May. This cotton has not got the appearance of Cambodia; the fibres are weak and staple short, about $\frac{3}{4}$ inch long. On the basis of *ujjain* at Rs. 520 on the day this may be valued at Rs. 570, Madras Cambodia selling for Rs. 650. A good sample of machine-ginned Cambodia has a nice golden tinge and a soft feel. The staple is about an inch long, spinning up to 40's. Gadag-Cambodia (roller-ginned) is only slightly inferior to the Madras-Cambodia but a saw-ginned sample is far inferior as the fibres are torn.

(2) *K 22* (an indigenous cotton evolved by Mr. Leake at Cawnpore). Value per acre Rs. 60-7-0, seed cotton 336 lb., ginning percentage 34, valuation per *candy* Rs. 415, good for 10's.

This also has deteriorated in the Central India soil and has acquired *bengal* style, having harsh feel and short staple.

(3) *Local Malvi.* Value per acre Rs. 58-9-0, seed cotton 356 lb., ginning percentage 30, valuation Rs. 430, and good for 10's.

(4) *Marwadi.* Value per acre Rs. 48, seed cotton 240 lb., ginning percentage 33, value per *candy* Rs. 475, good for 20's.

As regards future work in Central India, it should be emphasized that from the first the staff in charge should have a precise knowledge of what cottons actually exist in the tract and selections of all forms found in the field should be studied and tested on the experimental farm by officers who have had preliminary training in cotton investigation. The very fine variety *malvensis* is well worth detailed research and forms of it with a higher ginning percentage will undoubtedly be found if the search is conducted exhaustively.

Thanks are due to Messrs. Tata Sons & Co., Bombay, for their generous help in valuing the samples submitted

to them. This work takes up much valuable time which their staff have given ungrudgingly to assist us in the uphill task of effecting improvement in the Indian cottons.

III. Programme of work for 1919-20.

Major.

(1) To visit and advise on points regarding cotton and its cultivation whenever required to do so by the Provincial Departments of Agriculture.

Minor.

(2) An enquiry into the manurial requirements of cotton will be made.

(3) Researches on the botany of cotton will be continued.

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SCIENTIFIC REPORTS

OF THE

Agricultural Research Institute, Pusa

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Since the retirement of Mr. G. A. Gammie at the end of September 1919 no permanent arrangement has been made to fill up the post of the Imperial Cotton Specialist. No report of that officer is therefore to be found in this volume.

The Report of the Secretary of the Sugar Bureau, being not exactly of a scientific nature, has been published as an appendix.

SIMLA,
The 28th September,
1920.

S. MILLIGAN,
Director, Agricultural Research
Institute, Pusa.

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1919-20

REPORT OF THE DIRECTOR.

(S. MILLIGAN, M.A., B.Sc., AND G. S. HENDERSON, N.D.A., N.D.D.)

I. CHARGE AND STAFF.

Charge. Mr. G. A. D. Stuart, I.C.S., held charge of the office of Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, up to the 23rd October, 1919, and Mr. J. Mackenna, C.I.E., I.C.S., from the 24th October, 1919, to the 30th April, 1920. On the transfer of Mr. Mackenna to Burma as Development Commissioner, Dr. E. J. Butler, M.B., F.L.S., held charge from the 1st May till he was relieved by Mr. S. Milligan on the 18th June, 1920.

Dr. E. J. Butler held the post of Joint Director of the Institute until the close of the year, but subsequently proceeded on leave, Mr. G. S. Henderson, Imperial Agriculturist, relieving him of his duties as Joint Director.

Staff. Dr. W. H. Harrison proceeded on leave for 18 months from 1st May, 1920, when Dr. J. Sen, M.A., Ph.D., Supernumerary Agricultural Chemist, assumed charge of the duties of Imperial Agricultural Chemist. Dr. Sen's deputation under the United Provinces Government terminated on the 3rd December, 1919.

Mr. A. Howard, C.I.E., M.A., and Mrs. Gabrielle L. C. Howard, M.A., Imperial Economic Botanists, went on leave from the 26th November, 1919. Mr. G. P. Hector, M.A., B.Sc., Economic Botanist to the Government of Bengal, has officiated as Imperial Economic Botanist since the 20th December, 1919.

Mr. J. H. Walton, M.A., B.Sc., Assistant Agricultural Bacteriologist, has been appointed to act as Imperial Agricultural Bacteriologist from the 11th April, 1920, the date from which Mr. C. M. Hutchinson, C.I.E., B.A., proceeded on leave for 18 months. Mr. N. V. Joshi, M.Sc., B.A., L.Ag., First Assistant to the Imperial Agricultural Bacteriologist, acts as Assistant Agricultural Bacteriologist from the same date.

Dr. F. J. F. Shaw, Second Imperial Mycologist, has been on 11 months' leave from the 5th February, 1920.

Mr. Wynne Sayer, B.A., acted as Imperial Agriculturist up to the 4th January, 1920, when the permanent incumbent, Mr. G. S. Henderson, resumed charge on return from leave.

At the close of the year under report, Mr. J. F. Dastur, M.Sc., Supernumerary Mycologist, was still on deputation in England for training.

Mr. Afzal Hussain, B.A., M.Sc., Supernumerary Entomologist, was transferred as Entomologist to the Punjab Government on the 16th September, 1919.

Mr. W. A. Davis, B.Sc., A.C.G.I., Indigo Research Chemist, was on leave from the 11th October, 1919, to the 25th April, 1920.

Dr. A. P. Jameson, who has been appointed Protozoologist at Pusa, joined his duties on the 17th October, 1919.

Subsequent to the close of the year under report, Mr. F. M. Howlett, B.A., F.E.S., Imperial Pathological Entomologist, died at Mussoorie on the 20th August, 1920, after a serious operation. His death is a serious loss to the Institute and the Indian Agricultural Service.

II. Work of the Institute.

Scientific Work. The scientific work of the Institute during the year is described in the reports of the various sectional heads. A description of much of the work has already appeared in the form of Memoirs and Bulletins. The following is a summary of some of the items of more immediate importance.

Agricultural Section. The permanent experiments were continued on the lines of former years and the usual collaboration in field experiments with the other Sections of the Institute. The general farm area has been organized so as to provide a large-scale test of the maintenance of soil fertility under a double cropping system without irrigation, the principal crops being used as food for the dairy stock and consumed on the farm.

Data regarding the economics of " power " cultivation and the comparative value of various rotation crops are being collected.

The success of the cross-breeding experiments with cattle, so far as the first cross is concerned, is now assured.

The results of the combined cattle-breeding and fodder-raising experiments are clear on two important points, *viz.*,—

(1) that, for the production of milk, it is possible by crossing with an imported breed of high pedigree to improve on the milk outturn per head of the Montgomery cattle purchased in the Punjab, to the extent of at least 100 per cent.;

(2) that, where conditions permit, it is possible by the use of power on a fairly large scale to greatly reduce the production-cost of fodder.

It is now clear that the cost of production of milk for the large towns could be largely reduced by the breeding of cross-bred cows for the special purpose of milk production and the growing of cheap fodder on the lines adopted at Pusa.

Chemical Section. As recommended by the Conference of Agricultural Chemists, an investigation into the methods of analysis of nitrogen and phosphoric acid in manures and fertilizers has been undertaken by the Chemical Section. The important investigations regarding the retention of phosphoric acid in calcareous and non-calcareous soils reached a stage which enabled Dr. Harrison to submit the result for publication. The work on windrowing of sugarcanes started at Peshawar was continued at Pusa where it was found that the canes were capable of being windrowed under conditions of temperature much higher than those obtaining in the North-West Frontier Province. The question as to whether the roots of certain crop plants excrete toxic substances, and the comparative effect of ammonium sulphate as a manure for paddy used alone and in combination with green manures, formed some of the other important investigations made by this Section.

Botanical Section. Botanical work on wheat, indigo, linseed, tobacco, *patwa* (*Hibiscus cannabinus*) and safflower has been continued. In addition to this, work on rice and jute receives mention in the report of the Officiating Economic Botanist. Reports from the United Provinces indicate that some of the new Pusa wheat crosses sent out for trial may prove even higher yielders than the well established Pusa 12, showing an improvement in the direction of a stronger straw and better grain-holding properties. Botanical work on indigo was confined mainly to a continuation of observations on plants grown in drained and undrained lysimeters, to the monthly examination of roots, and to seed selection. Definite results have been obtained from the work on linseed, indicating the lines on which improvement of the Bihar varieties must proceed.

The Officiating Economic Botanist, in collaboration with the Fibre Expert to the Government of Bengal, continued the investigations into "chlorosis" in jute which promise to have important practical results in eliminating this danger to the Bengal jute crop.

The Mycological Section was short-handed during the greater part of the year owing to the absence of two of the superior staff. The work on the black band disease of jute, rot in potatoes during storage, and on the diseases of fruit in Kumaon have, however, yielded important results. Diseases of cereals have been under investigation and considerable progress has been made in the enquiry which is likely to extend over several years. Observations at Lyallpur of the root-rot of cotton have led to the conclusion that this disease which occurs sporadically in Northern and Western India is a non-parasitic one and is associated with some unknown soil condition which will require special study.

Entomological Section. In additi n to systematic work on insects, the Entomological Section continued the investigation of the relative immunity of varieties of cotton from bollworm attack, of borer pests of sugarcane, rice and other cereals, and of other agents of damage to these crops which produce effects similar to those caused by borers. The Imperial Entomologist, in emphasizing the importance of the study of the stem borers, estimates that the average loss of sugarcane in India through the action of borers amounts to 10 per cent. of the total crop. Considerable material has been accumulated regarding insect pests of fruit trees. The results of the prolonged experiments and the details of the successful methods on the storage of grain against insect attack have been fully described in a paper by Mr. Fletcher and Mr. C. C. Ghosh. Further work on pests of stored grain was mainly directed to finding whether there is any infestation in the field and, if so, to what extent. Lac and sericulture also continued to engage the attention of this Section.

Pathological Entomological Section. On the conclusion of his deputation to investigate the mosquito repellents, the late Mr. Howlett worked on the effects of alkaloidal poisons on rats and of X-rays on mosquito larvæ in collaboration with Captain Barnard of the Colaba Hospital.

Attempts were also made to discover the insect-carrier of a short period fever which was seriously impairing the efficiency of ship's crews in the Bombay Docks. At the time of his death Mr. Howlett was engaged on a survey of flies in the Punjab and the North-West Frontier Province in connection with the transmission of surra amongst camels.

Bacteriological Section. A large amount of work on nitrification and fixation of nitrogen has already been done by the Bacteriological Section. During the year under report, investigations were carried out regarding the nitrification of cow-dung, cow-urine and sheepfold manure, along with their effects on plant growth. The losses of nitrogen during the storage of these manures are being further investigated. A study of the wide variations in the accumulation of nitrate during the decomposition of various oil-cakes tends to the conclusion that these are intimately connected with the carbohydrate-nitrogen ratio of the cakes, the oil content having apparently very slight influence on nitrification. A comparison of the nitrogen content of soil under fallow and growing crops showed that not only the nitrate but also the organic nitrogen content of the cropped plots were lower than those of the fallow plot. Further work on the sterilization of water by the new sterilizer (electro-chlorogen), mentioned in last year's report, was continued.

Protozoological Section. Dr. Pringle Jameson, who joined his appointment on the 17th October, 1919, has taken up the work on the pebrine disease of silkworms from the point where Mr. Hutchinson, who initiated the investigations, left off.

The work done by the *Indigo Section* is published in a special series of Indigo Publications started by the Institute. A separate annual report has, therefore, not been considered necessary.

Training. The number of post-graduate students under training at the Institute, during the year, are

given below. In addition, short courses have been given in sericulture.

	Number of students
General Agriculture	3
Agricultural Chemistry	1
Mycology	2
Economic Entomology	1
Agricultural Bacteriology	1
Sericulture	5
TOTAL	13

In addition, Mr. T. P. Padmanabha Pillai, Mycologist, Travancore State, spent a month in the Mycological Laboratory, and a stipendiary student from Ajmer-Merwara underwent a training in general analytical methods for three months in the Chemical Laboratory. Two students sent from the Agricultural College at Sabour were also given instruction in sericulture not amounting to a regular course.

III. PUBLICATIONS.

Six Memoirs, nine Bulletins, one Indigo Publication, and three pamphlets were issued during the year, while 32 publications were in the press at the close of the year.

The proceedings of four conferences, *viz.*, the Eleventh Meeting of the Board of Agriculture, the Second Meeting of Mycological Workers, the First Meeting of Agricultural Chemists and Bacteriologists, and the First Meeting of Veterinary Officers, were also brought out during the year, and the Report of the Proceedings of the Third Entomological Meeting, an octavo volume of 1,138 pages of print and 182 plates, was still in the press on the 30th June, 1920.

The issue of the "Agricultural Journal of India" every two months, instead of every quarter, has further stimulated its circulation, and, with the commencement of the New Year, it is proposed to further increase the print order by 250 copies to meet the growing demand.

IV. Accounts.

The total expenditure during the financial year ending the 31st March, 1920, was Rs. 6,59,343 as against Rs. 6,06,640 during the previous year. The details are given below:—

	Rs.
General expenditure on the Institute (including the Office of the Agricultural Adviser and Director)	2,61,236
Chemical Section	39,856
Mycological Section	45,983
Entomological Section	54,089
Pathological Entomological Section	31,259
Bacteriological Section	39,077
Botanical Section	45,261
Agricultural Section	87,381
Indigo Research Section	51,838
Protozoological Section	3,363
Total	6,59,343

A sum of Rs. 15,000 was paid as a grant-in-aid to the Indian Tea Association.

The principal items of expenditure under the annual grant of Rs. 10,000 placed at the disposal of the Agricultural Adviser to the Government of India for special agricultural experiments were as follows:—

	Rs.
For investigation of anti-scorbutic and anti-beriberi properties of sun-dried vegetables	2,000
Cost of fencing materials	993
Entertainment of visitors during motor tractor demonstrations	747
Pebrine experiments	246
Cost of oil for surra experiments	500
Apparatus and appliances for the Mycological Section at Pusa	1,409
Experimental cotton cultivation by the Imperial Cotton Specialist, Poona	1,000
Mosquito experiments at Pusa	316
Pay of a Veterinary Assistant	541

The gross receipts during the year from the sale of farm produce, milk, publications of the department and other articles amounted to Rs. 36,221 as against Rs. 21,403 last year.

V. Conference.

The Eleventh Meeting of the Board of Agriculture in India was held at Pusa from the 1st to 6th December, 1919, under the presidency of Mr. James Mackenna, C.I.E., I.C.S. The meeting was attended by 49 members and 27 visitors, the latter including the Hon'ble Sir Claude Hill, Member-in-charge of the Department of Revenue and Agriculture, Government of India, the Hon'ble Mr. R. A. Mant, Secretary to the Government of India, Department of Revenue and Agriculture, and the Members of the Indian Sugar Committee.

REPORT OF THE IMPERIAL AGRICULTURIST.

(G. S. Henderson, N.D.A., N.D.D.)

I. Charge.

Mr. Wynne Sayer held charge of the post of Imperial Agriculturist till the 4th of January, 1920, when the permanent incumbent took over charge.

Khan Sahib Mohammed Ikramuddin was appointed to the post of Assistant to the Imperial Agriculturist on 13th August, 1919.

Khan Bahadur Judah Hyam retired from service on 25th August, 1919, and Mr. L. S. Joseph was appointed as Cattle Superintendent.

II. General.

An important part of the work of the Imperial Agriculturist is to act as liaison officer to the various provincial agricultural authorities in India. During the past year little in this direction was possible, Mr. Sayer being employed on the Indian Sugar Committee during most of the year and during the remaining months the writer has, among other general work, been occupied with a scheme for motor tractor trials and proposals for an Agri-Irrigation Research Institute. A number of tours were, however, undertaken in connection with these proposals. A full scheme was drawn up for the proposed Irrigation Research Institute in consultation with Mr. T. R. J. Ward, Inspector-General of Irrigation, and Mr. Roberts, of the Punjab Agricultural Department.

A consultation was held with Mr. Smith, the newly appointed Imperial Dairy Expert, regarding the place of the Pusa herd in the general scheme for the improvement of cattle-breeding in India. In the new dairy schemes being worked out for various provincial departments the agricultural part of the programme will be drawn up by the Imperial Agriculturist.

The second and fourth classes of agricultural students were examined at Lyallpur, Punjab. These students were found to be of a useful and practical type, and show promise of being of great value to the future agricultural development of the Punjab.

III. Publications.

A Bulletin entitled "Practical notes on Salt Land Reclamation" was issued during the year. The Guide to the farm at Pusa was brought up to date, and the preliminary work for a Bulletin on details and costs of the different farm crops at Pusa was completed. Various notes and reviews for the "Agricultural Journal of India" were completed. A large number of agricultural enquiries from all parts of India were replied to.

IV. Training course.

While there is at present no definite post-graduate course in agriculture at Pusa, graduates are admitted to study farm practice and management of the dairy herd. Three students were admitted during the year under review.

V. Pusa Farm.

The farm is under the Imperial Agriculturist, and, as has been explained in former reports, consists of about 500 acres of arable land and 400 acres grazing in addition to a carefully prepared experiment area. The whole is laid out so as to permit of its being worked on up-to-date practical lines and operated with such western machinery and implements as are suited to Indian agriculture. The produce of the farm is used in the upkeep of the pedigree dairy herd. The whole concern is very cheaply run and is, from the strictly financial point of view, a good investment for Government.

The Season. The season was an abnormally dry one, the total rainfall amounting to 32·73 inches as against 60·19 inches for the previous year. Sowings went on intermittently during the scanty rainfall in the first three weeks

of June and were not completed till July. The pulse crop was consequently sown too late. The shortage of rainfall continued during the monsoon. Two inches of rain in October, however, facilitated the sowing of the *rabi* (winter) crop. Drought again intervened till February 1920 when rain saved the oat crop from total failure but was too late for straw. The *arhár* (*Cajanus indicus*) crop which was flowering at the time suffered a great deal and yielded disappointingly. The monsoon, though light, was not unfavourable to the maize grown for grain, but that grown for green fodder was much below normal.

The Pusa Farm is worked under a three-year 6-course rotation given below. The land is double-cropped, *i.e.*, two crops are taken off the same land annually.

	1st Year	2nd Year	3rd Year
Monsoon crop (*Kharif*) . .	Maize for silage and fodder	Maize for corn	Pulse green crop
Winter crop (*Rabi*) . . .	Oats . .	*Arhar* (*Cajanus indicus*)	Oats

Details are as follows :—

1st year's rotation. The land under maize is given 10 tons farmyard manure or 10 maunds oil-cake and is followed by oats in the *rabi*. During the year under report five fields aggregating 125 acres were put down under maize and *juar* (*Andropogon Sorgum*). The best yield was got from South Pangarbi field where 15 acres gave 220 maunds per acre of green fodder, the best yield of oats being 14½ maunds per acre from Brickfield No. 2.

The working cost for the year for both *kharif* and *rabi* crops in this year of the rotation amounted to Rs. 56-4* per acre and the return to Rs. 88-2, giving a working profit of Rs. 31-14 per acre for the year.

2nd year's rotation. No manure is given to the crops in the second year of the rotation. As a rule maize and *arhar*

* Exclusive of rents, rates and taxes and supervision charges.

PLAN OF PUSA FARM

(ARABLE AREA)

SCALE 4"=1 MILE

PLATE I.

CATTLE FEEDING ON THE LEGUMINOUS CROP GUAR.

are sown together so that the *arhar* remains as a *rabi* crop after the removal of the maize, thereby saving a considerable amount of cultivation at the busiest time of the year. The total area under this rotation was 140 acres out of which 119 acres were sown under maize and *arhar*.

The working costs for the year for all crops in this rotation were Rs. 22-10* per acre and the returns Rs. 96, giving a profit of Rs. 73-6.

The season was a fair one for maize corn and the best field Bhograson gave 14½ maunds, the average over all being nearly 9 maunds. The *arhar* crop, as mentioned above, finished badly owing to rain at the wrong time in February 1920 when the crop was in full flower.

3rd year's rotation. In the 3rd year's rotation pulse crops are sown in *kharif* and fed off on the land. Four fields aggregating 132½ acres were sown under *guar* (*Cyamopsis psoralioides*), soybeans, *math* (*Phaseolus aconitifolius*), cowpeas and velvet beans. Out of this, 107 acres were fed off and 25 acres of *guar* in Chhoania field were cut green for stall-feeding. The latter area was subsequently sown with oats manured with 5 maunds of oil-cake per acre to make up for the removal of the crop.

The soiling began late (the 3rd of August), the sowing of the crop having been delayed by late rainfall. Two hundred and sixty-six head of cattle consumed an average of 2·6 acres of crop daily over a period of 40 days (Plate I).

Oats followed the pulse crop over 88 acres, 4 acres being left fallow for next year's sugarcane and hot weather maize and a small area reserved for wheat. The oats area received a dressing of one maund of superphosphate.

The best yield was 12½ maunds from Chhoania, the average being 11 maunds. Working cost was Rs. 32* per acre and return Rs. 53.

Sugarcane. The land for this crop is kept fallow during *rabi*, the moisture being conserved by repeated harrowings till the cane is planted in February without

* Exclusive of rents, rates and taxes and supervision charges.

irrigation. This year eight acres were under cane. A dressing of half a ton of oil-cake was applied per acre, half at planting time and the remainder on the first rainfall. The crop yielded an average of 472 maunds per acre and was sold to the factory at annas 11 per maund. The cost of production amounted to Rs. 116-9, and the return Rs. 231-8 per acre. Twelve selected varieties were grown, *viz.*, thick canes : Sathi, Purple Mauritius, Kaludai Budan, D. 99 American and D. 1135; Thin canes : Java 36, Mungo, Yuba, Saretha, Maneria, Kuswar and Reora. Twenty-nine varieties received from Dr. Barber, Government Sugarcane Expert, were also grown for comparative tests on small areas. Out of these, Co 215, Co 201, Co 202, Co 204, Co 205, Co 206, Co 207, Co 208, Co 210, Co 213, Co 214, Java 213, Kuswar and Tobe Monjet did well and are this year being tried on a large scale. The thick canes are planted in rows 3 feet apart while the spacing of the rows for the thin varieties is $2\frac{1}{2}$ feet. This method of planting has been found the quickest and most economical in regard to labour. Furrows are opened by a ridging plough, followed by a sub-soiler to loosen the soil to a depth of about 9 inches. Sets are then laid horizontally in the furrows followed by a top-dressing of oil-cake. The sets are then covered by a special implement which is a combined *hanga* and roller.

Jute. 21·53 acres in Goojarmalla field were sown under jute for seed for the Fibre Expert to the Government of Bengal. The field is liable to flooding, but on account of the scanty monsoon rainfall the crop grew well and yielded 134 maunds of seed or an average of 6·25 maunds per acre.

Berseem. Berseem or Egyptian clover (*Trifolium alexandrinum*) was sown on an area of 8·46 acres commanded by irrigation from the river. This is a most promising fodder crop, providing fodder between seasons at a time when there is a scarcity of green food. An area of over 40 acres has now been levelled for the extension of this crop under irrigation. The fodder will be of great value to the milch stock.

Soiling. The practice of grazing fodder crops on the land has been found to be of great practical value. It now forms part of the rotation designed to determine if it is feasible to maintain the fertility of ordinary rain-watered land under intensive cropping. With irrigated land the matter is comparatively simple, but in rain-watered land the maintenance of fertility by simple practical methods is one of the most urgent of agricultural problems.

VI Permanent Experiments.

These were continued in the two fields specially laid out for the purpose.

(*a*) The permanent manurial and rotational experiments were continued. The results obtained up to the year 1918-19 were discussed by a sub-committee held at the time of the last Board of Agriculture.

The object of this series is to determine the specific effect on soil fertility of the more common organic and chemical manures applied alone and in various combinations to a two-year 4-course rotation.

Table I showing the treatment and results of outturns for the year 1919-20 is given below :—

TABLE I.

Plot No.	Treatment	"A" Series		"B" Series	
		Maize	Oats	Maize	Arhar
		lb.	lb.	lb.	lb.
1	No manure	693	489	382	864
2	Farmyard manure to supply 10 lb. nitrogen .	829	581	471	924
3	Farmyard manure to supply 20 lb. nitrogen .	1,056	614	772	1,271
4	Farmyard manure to supply 30 lb. nitrogen .	1,251	733	779	827
5	Rape cake to supply 20 lb. nitrogen .	874	532	546	910
6	Sulphate of ammonia to supply 20 lb. nitrogen	433	357	244	1,002
7	Sulphate of potash to supply potash as in farmyard manure No. 3	417	358	261	830
8	Superphosphate to supply P_2O_5 as in farmyard manure No. 3	795	712	652	476
9	Sulphate of potash to supply potash as in farmyard manure No. 3; Superphosphate to supply P_2O_5 as in farmyard manure No. 3	790	617	850	476
10	Sulphate of ammonia to supply nitrogen as in farmyard manure No. 3; Sulphate of potash to supply potash as in farmyard manure No. 3 and superphosphate to supply P_2O_5 as in farmyard manure No. 3	790	622	1,064	618
11	Green manure and superphosphate to supply P_2O_5 as in farmyard manure No. 3	..	1,017	1,466	790

(*b*) The green-manuring experimental plots designed in collaboration with the Imperial Agricultural Bacteriologist were continued for the purpose of testing residues. The yields from the different plots are not included in this report as they show no departure from last season's results.

(*c*) The experiments in collaboration with the Imperial Mycologist regarding a method of dealing with die-back disease in chillies were continued.

(*d*) Six wheat varieties, Federation, Pusa 12, Pusa 4, Cawnpore 13, Maroo Booji, and Lyallpur 8A, which yielded well last year, were grown in a series of plots. The results owing to the deficiency of rainfall were in many cases very poor. The highest yield was 24 maunds 25 seers per acre from Federation, while the highest outturns of Pusa 4, Pusa 12 and Cawnpore 13 were 15 maunds, 21 maunds, and 18 maunds respectively.

(*e*) The experiments for comparing the comparative economic value of the common leguminous crops were continued. There are two series of plots in this experiment. One series is grown with *kharif* pulses to produce green fodder in the *kharif* and is followed by winter pulses for grain in the *rabi* season; the second series is for testing grain outturn of both *kharif* and *rabi* pulses.

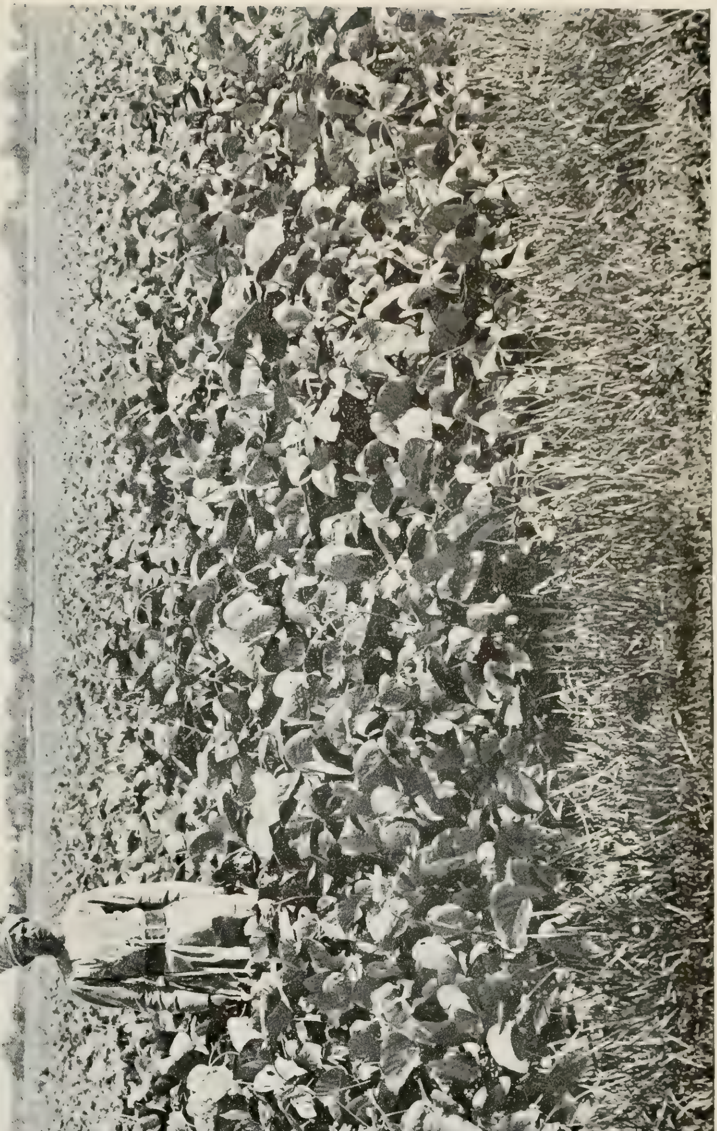
The table below shows this year's results :—

TABLE II.

"A" Series.

Kharif pulses	Green fodder per acre in lb.	How dealt with		Rabi pulses	Weight of seed per acre in lb.
		Fed to cattle	Left by cattle		
1. Soybeans . . .	9,453	5/6	1/6	Val . . .	953
2. Cowpeas . . .	14,513	All	..	Lentils . . .	597
3. Florida velvet beans .	9,848	2/3	1/3	Purple peas . . .	493
4. Florida Beggar weed .	5,692	2/3	1/3	White peas . . .	392
5. Math	14,710	All	..	Gram, small Kabuli .	400
6. Urid (*Phaseolus radiatus*)	11,704	13/14	1/14	Gram, Cawnpore . .	770
7. Guar	9,527	6/7	1/7	Gram, local, Pusa Bihar.	452
8. Val (*Dolichos lablab*) .	4,033	2/3	1/3	Gram, yellow, of Gujarat District	448

PLATE II.



VELVET BEANS FOR GREEN-MANURING.

"B" Series.

Kharif pulses	Weight of seed per acre in lb.	Rabi pulses	Weight of seed per acre in lb.
1. Soybeans	1,135	Fallow as kharif crop was harvested late	..
2. Cowpeas	825	Ditto .	..
3. Florida velvet beans . . .	1,248	Ditto .	..
4. Florida Beggar weed . . .	127	Gram, Kabuli big .	353
5. Math	1,107	Fallow as kharif crop was harvested late	..
6. Urid	610	Ditto .	..
7. Guar	1,068	Ditto .	..
8. Val	562	Same crop standing in rabi .	..

Series A. Almost all the *kharif* pulses grown yielded well except *math*, *guar*, and velvet beans, which gave a less outturn of green fodder than last year, probably on account of the late arrival of the monsoon which delayed sowings. The cowpeas and *math* grown as green fodder were consumed by the farm stock.

In the case of the *rabi* pulses the yield of grain amounted to about one-half of last year's outturn on account of the late winter rains in February which fell when the crop was just in flower. The Yellow Gujarat and the local gram suffered most.

Series B. The grain yield of *kharif* pulses is high as compared with that of last year, but the late ripening of the crop prohibited the sowing of the succeeding *rabi* pulses.

(*f*) Experiments with Java and Sumatrana indigo conducted in collaboration with the Indigo Research Chemist and the Imperial Agricultural Bacteriologist, and the wilt disease experiments in collaboration with the Imperial Mycologist and the Fibre Expert to the Government of Bengal, were continued. These experiments will last over a period of years and the results will be dealt with from time to time by the Indigo Research Chemist and the Imperial Mycologist in their respective reports.

As in past years, crops were grown in the North Pangarbi field for the other Sections.

VII. Implements and Machinery.

Steam Ploughing Tackle. The set of tackle consisting of two single cylinder "K" class Fowler engines with steel wire rope and four furrow anti-balance gang plough, a disc harrow, a grubber, a zigzag harrow and a Crosskill roller, worked during the year for 126 days of 10 actual working hours each. The engines were also used for silage cutting and for driving an 8-inch centrifugal pump for irrigation both in the monsoon and cold weather seasons when there was no cultivation work to be done on the farm.

The cost of the set in 1913 was as follows :—

	Rs.
Two engines with steel cables	30,000
Plough	3,700
Disc harrow	3,625
Grubber	3,227
Zigzag harrow and roller	2,925
Total	43,477

Details of output, fuel consumption and working costs, including all expenses except depreciation and interest on outlay, are given below.

TABLE III.

Output, consumption and cost of Steam Tackle during 1919-20.

(a) *Output.*

Year	Working days	SUMMARY OF WORK DONE										AVERAGE WORK IN ACRES PER DAY			
		PLOUGHING		DISC HARROWING		GRUBBING		ROLLING		TOTAL		Ploughing	Disc harrowing	Grubbing	Rolling
		Days	Acres	Days	Acres	Days	Acres	Days	Acres	Days	Acres				
1919-20	126	53	404·5	28	582	22	488	23	533	126	2007·5	7·6	20·7	22·1	23·1

(b) *Consumption of fuel, etc.*

Year	Days in work	COAL AND WOOD		ENGINE OIL	CYLINDER OIL	GREASE	WASTE
		TOTAL	PER DAY				
		Mds. Srs. Ch.	Mds. Srs. Ch.	Mds. Srs. Ch.	Mds. Srs. Ch.	Mds. Srs. Ch.	Md. Srs. Ch.
1919-20	126	4,032 10 0	32 0 0	11 37 0	3 22 8	0 28 0	1 12 13
		103 35 0	0 33 0				
		4,136 5 0	32 33 0				

(c) *Cost.*

Year	Days	ANALYSIS OF TOTAL COST						COST PER ACRE			
		Labour	Coal and Wood	Lubricating Oil	Miscellaneous	TOTAL	Per day	Ploughing	Disc harrowing	Grubbing	Rolling
		Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
1919-20	126	1,200 6 5	1,622 8 11	633 3 7	1,195 15 3	4,652 2 2	36 14 9	4 13 8	1 12 6	1 10 8	1 9 6

TABLE IV.

Showing cost for working and maintaining the Steam Tackle in 1916-17, 1917-1918, 1918-19, and 1919-20.

Particulars	1916-17 No. of working days 151 Cost	1917-18 No. of working days 121 Cost	1918-19 No. of working days 145·4 Cost	1919-20 No. of working days 126 Cost
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Labour	1,233 0 0	940 1 6	933 10 9	1,200 6 5
Coal	1,788 0 0	1,424 9 0	1,655 13 9	1,622 8 11
Oil	300 0 0	315 0 0	481 14 9	633 3 7
Miscellaneous stores, etc., and renewals	713 0 0	3,418 13 9	1,064 4 1	1,195 15 3
TOTAL .	4,034 0 0	6,098 8 3	4,135 11 4	4,652 2 2

TABLE V.

Showing the above costs divided into following operations per acre in the years 1916-17, 1917-18, 1918-19, and 1919-20.

Particulars	1916-17			1917-18			1918-19			1919-20		
	Total area cultivated in the year	Cost per acre	Best day's work	Total area cultivated in the year	Cost per acre	Best day's work	Total area cultivated in the year	Cost per acre	Average per day	Total area cultivated in the year	Cost per acre	Average per day
	Acres	Rs. A. P.	Acres	Acres	Rs. A. P.	Acres	Acres	Rs. A. P.	Acres	Acres	Rs. A. P.	Acres
Ploughing	267	4 6 2	7	170·5	9 3 2	7	373·5	3 14 4	7·3	404·5	4 13 8	7·6
Disc harrowing	498	2 0 9	18	821·5	3 0 3	20	605·5	1 11 9	16·4	582·0	1 12 6	20·7
Grubbing	1,080	1 7 4	25	616·0	4 5 7	26	668·0	1 6 0	20·7	488·0	1 10 8	22·1
Zigzag harrowing . . .	41	0 14 9	27	11·0	2 2 6	..	..	..	..	..	..	..
Rolling	320	1 5 6	22	173·0	3 14 0	22	540·0	1 5 8	21·0	533·0	1 9 6	23·1
TOTAL	2,206	..	..	1,792	..	..	2,187	..	..	2,007·5	..	..

Fordson Tractor. After a trial and demonstration with implements used on the farm in May 1919 this machine was bought for Rs. 4,362 from Messrs. the Russa Engineering Works, Ltd., Calcutta, for further trials as regards fuel consumption and work. The tractor has now worked on the farm for fully a year in both *kharif* and *rabi* cultivation. The implements used include Ransome's double disc plough, a two 14-inch furrow Oliver plough No. 7, a Roderick Lean disc harrow, spring tooth harrows, a Cambridge roller and an Orwell spring tyne cultivator : also a Raja reaper for harvesting oats. The work of the Orwell cultivator and Roderick Lean disc harrow when used in conjunction with the tractor has been found excellent. The Raja reaper is too small for economic results and a self-binder would be more satisfactory. The tractor also did very good work in driving a Climax silage cutter for chaffing green maize and *juar*. Figures of output, consumption and cost excluding depreciation and interest are given below.

TABLE VI.

Out put, consumption and cost of Fordson Tractor during 1919-20.

(a) *Output.*

Year	Working hours	SUMMARY OF WORK																		ACREAGE PER HOUR					
		PLOUGHING		DISC HARROWING		GRUBBING		Rolling		Drilling		Reaping		TOTAL		BELT PULLEY WORK	GRAND TOTAL			Ploughing	Disc harrowing	Grubbing	Rolling	Drilling	Reaping
		Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Hours work	Acres							
1919-20	892·5	357·8	188·45	249	317·5	111·95	203·5	39·25	63	..	..	83	84	841	856·45	51·5	892·5	856·45		0·526	1·275	1·817	1·60	..	1·012

(b) *Consumption.*

Year	Working hours	FUELS	ENGINE OIL		GEAR OIL		GREASE	WASTE
		Total gallons	Gallons per hour	Total gallons	Gallons per hour	Total gallons	lb	lb
1919-20	892·5	Kerosine . 1,387·5 Gasoline . 35·7 TOTAL . 1,423·2	1·59	178·0	0·199	7	34	3·2

(c) *Cost.*

Year	Working hours	ANALYSIS OF TOTAL COST						COST PER ACRE					
		Labour	Fuel: Kerosine and Gasoline	Lubricants, etc.	Miscellaneous and renewals	TOTAL	Per hour	Ploughing	Disc harrowing	Grubbing	Rolling	Drilling	Reaping
		Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
1919-20	892·5	282 13 6	1,303 3 9	1,049 9 7	244 10 0	2,880 4 10	3 3 8	6 2 3	2 8 6	1 12 8	2 0 2	..	3 3 0

Austin Tractor. This machine was bought from Messrs. A. H. Wheeler & Co., Allahabad, for Rs. 3,268 and arrived on the farm in January 1920. It did equally good work to that of the Fordson with the same implements and was also used for breaking in land from jungle.

The following statement shows the output, consumption and cost during the period of three months' working.

TABLE VII.

Output, consumption and cost of Austin Tractor during three months of working.

(a) *Output.*

Year	Summary of work									Acreage per hour		
	Working hours	Ploughing		Disc harrowing		Reaping		Total		Ploughing	Disc harrowing	Reaping
		Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres			
1920	301·5	120·5	53·55	87	116·5	94·0	88·0	301·5	258·05	0·44	1·33	0·93

(b) *Consumption.*

Year	Working hours	Fuel	Engine oil		Gear oil		Grease	Waste
		Total gallons	Gallons per hour	Total gallons	Gallons per hour	Total gallons	lb.	lb.
1920	301·5	423·5 Kerosine . 410 Gasoline 13·5	1·40	30	0·099	6	10	1·0

(c) *Cost.*

Year	Hours	Analysis of total cost						Cost per acre		
		Labour	Fuel. Kerosine and Gasoline	Lubricants, etc.	Miscellaneous and renewals	Total	Per hour	Ploughing	Disc harrowing	Reaping
		Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P
1920	301·5	84 5 9	390 10 11	205 8 0	3 8 0	684 0 8	2 4 4	5 2 7	1 11 4	2 7 0

The work of these two tractors have clearly shown the necessity for extensive trials of standard makes in India. It is possible that a number of modifications will have to be introduced before tractors can be recommended for ordinary zemindari conditions. The importance to India of the tractor movement is enormous. Plough cattle of powerful type are scarce and dear, and improved agriculture necessitates more power. It is useless to recommend an increased area of, say, sugarcane cultivation, unless means are provided for the extra power required for an increased depth of cultivation. A motor tractor equals in work 8—10 pairs of cattle. The subject is thus worthy of more attention than a few spasmodic demonstrations. Further, the introduction of tractors necessitates the provision of training schools for drivers and workshops for running repairs within easy reach.

The agricultural machinery trade in India is at present in an unsatisfactory state. Makers have no direct representatives in India but are represented by agents in the large towns. There are no stocks in the country and spare parts are increasingly difficult to get, and for these exhorbitant prices are sometimes charged. For example, a bill was presented for Rs. 1,200 for spares for a couple of reaping machines. Makers will undoubtedly have to contemplate the appointment of their own agents and the opening of depôts in upcountry districts.

It is obvious that the work of the Agricultural Departments in India must include both the testing of standard types of agricultural machinery and the adoption of such suitable modifications as are required by Indian and individual district conditions. This class of work is quite in its infancy and requires considerable capital and time. Agriculturists in India are further handicapped by the difficulty of getting into direct touch with manufacturers in England and America.

VIII. Pedigree Dairy Herd.

During the year under report this herd has progressed satisfactorily. As has been shown in former reports it is divided into two sections :—

(*a*) A pure bred Montgomery or Sanhiwal herd.

(*b*) A cross bred herd obtained by crossing the poorer Montgomery cows with Ayrshire bulls.

(*a*) **The Montgomery Herd.** The strict selection for milk yield is now giving results and the herd is slowly but steadily improving. It numbers over 244 head and it is hoped to reject this year all cows giving less than 3,500 lb. of milk in a lactation period of 10 months from calving.

It is satisfactory to record that a number of the new heifers have started with yields of over 3,500 lb. in their first lactation period of 10 months; as they are still in milk their names are not included in the list below.

The best results in the past year in the Montgomery section are :—

Table VIII.

Name of cow	Milk yield in lb. (10 months)	Sire	Dam	Dam's best yield in lb.
Joogni 142	6,457	Amritsari	Bowdhi 33	4,810
Syria 182	6,312	Amritsari	Godhi 99	5,954
Roomali 140	5,007	Amritsari	Banthi 37	4,228
Bhawani 214	4,454	Behari	Thombi 130	4,192
Chakli 203	4,317	Prayagi	Padmini 56	3,770
Anjani 210	4,247	Behari	Makhni 28	4,406
Ashrafi 211	4,217	Prayagi	Panji 39	4,665

The calves from the Montgomery heifers are now being weaned at calving time but great care and careful supervision is necessary. When the calf is weaned the cow takes the bull sooner and more regularly.

(*b*) **Cross Bred Herd.** The number of the cross bred herd is at present 91 head.

The best of the cows were :—

TABLE IX.

Name of cow	Milk yield in lb. (10 months)	Calving	Dam	Dam's best yield in lb.
Alibi No. 3	7,765	2nd	Sajni	3,921
Naomi No. 1	7,019	2nd	Thoombri	3,934
Daisy No. 5	6,481	2nd	Gujri	4,416
Kitty No. 10	5,089	1st	Makdi	..
Patty No. 8	5,600	1st	Rangeli	3,333
Peggy No. 9	5,895	1st	Phekni	3,519

The above results are very striking. The combined results at Pusa and at the various military dairies, in which records of hundreds of animals and over 10 years' experience are available, show that a cross of the well bred Ayrshire bull with an Indian cow will double the average milk yield of the Indian breed. The cross cow, too, comes in calf regularly and the calf can be weaned without difficulty.

The following table shows the yields of two cross cows, Jill, belonging to the Military Dairy, Bangalore, and Alibi at Pusa (Plate III).

TABLE X.

Lactation period	JILL (BANGALORE)		ALIBI (PUSA)	
	Number of days in milk	Yield in lb.	Number of days in milk	Yield in lb.
First	347	7,979	304	7,271
Second	306	8,031	304	7,989
Third	282	9,457	...	...
Fourth	303	11,329	...	...
Fifth	366	13,564	..	...

Fig. 1. Cross bred Cow "Jill" (Bangalore).

Fig. 2. Cross Ayrshire-Montgomery Cow "Alibi" (Pusa).

Total days from first calving of Jill to day prior to last calving, 1,944. Total yield, 50,360 lb. Daily average, 25·90 lb. Present yield from 21st March, 1918, to 31st October, 1918, is 9,800 lb. and still doing 30 lb. daily (October 1918). Per cent. butter fat, morning 4·44, evening 4·46.

From 1st April, 1920, to 30th July, 1920, Alibi has given 5,228 lb., giving an average daily yield of 43·2 lb. milk and is now giving 38 lb. milk per day.

It is obvious that cows of this type are enormously valuable. A cow giving 10,000 lb. milk in a year with the retail price of milk at 2 seers to the rupee is worth taking some care of. With reference to the comparative quality of the milk of the cross bred and Montgomery herds the average of a number of bulk samples showed about the same high content of butter fat for the two, *viz.*, 4·6 per cent.

Much criticism has been evoked on the subject of cross-breeding on the score of susceptibility to disease. This, however, is largely discounted by actual experience at the military dairies where rinderpest has been successfully combated by the method of simultaneous inoculation. Other cattle diseases are not nearly so dangerous. The main line of work in this connection is only at the beginning, *viz.*, the selection of a fixed type from among the cross breds. The ideal type of animal would combine disease resistance derived from the female side with the milk yield derived from the Ayrshire stock. To make headway with this work large numbers are essential and the addition of other stations is required.

IX. Sales.

A sale of surplus stock was held in March and was well attended. Thirty head realized nearly Rs. 7,000.

X. Staff.

The staff of the Agricultural Section, Pusa, though very short-handed, worked with great zeal during the year.

XI. Programme of work for 1920-21.

Major.

I. Co-ordination of work in the various Agricultural Departments by touring, etc.

II. Practical treatment of the Pusa Farm with special reference to suitable modern machinery and the economic results thereof.

III. Practical treatment of the Pedigree Dairy Herd and the fixing of a cross bred type of milk animal.

IV. Experiment work in collaboration with the various scientific Sections at Pusa as mentioned in the various sectional reports.

V. Rotation and fertility experiments on a field scale and the trial and acclimatization of new crops.

VI. Demonstrations and sales at Pusa.

Minor.

VII. General advisory work of an agricultural nature.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(J. Sen, M.A., Ph.D.)

I. Administration.

Dr. W. H. Harrison was in charge of the Section till the 30th April when he proceeded on leave. After that I have been appointed to officiate in his place.

II. Education.

Mr. A. K. Mitra, B.Sc., stipendiary student of the Bihar and Orissa Government, completed his course of training in agricultural chemistry in March.

Mr. K. M. Banthia, B.Sc., stipendiary student from Ajmer-Merwara, underwent a training in general analytical methods for three months in this laboratory.

III. Meteorology and drain-gauges.

The usual meteorological records were maintained. The crops and drainage waters from the drain-gauges were examined in the usual manner.

IV. General analytical work and assistance given to other sections.

A. The following samples were analysed and reported upon during the year :—

Soils	37
Manures	24
Feeding stuffs	22
Sugarcanes	60
Milk	8
Cotton seeds	40
Waters	26
Paddy husk ashes	2
Insecticide	1
Fungicides	2
Fire clay	1
Slaked lime	1

Stomach contents and livers of bulls . .	3
Miscellaneous	2
	229

Among the items of interest in this connection were samples of the commercial insecticides known as *Polvo* and *Katakilla*. *Polvo* is a powder which upon microscopic examination is shown to be of vegetable origin. The aqueous extract consisted largely of dextrinoid, resinoid matters with some small proportion of tannin. No specific alkaloids could be detected and the active principle appeared to be a sapotoxin. This was confirmed by its isolation and reactions, both chemical and biological. There appeared to be about 0·97 per cent. present in the sample. *Katakilla* seemed to be a mixture of *Polvo* with soap.

B. The following assistance was rendered to other Sections :—

Agricultural Section. Forty-four samples of sugarcane, 15 samples of manures and 4 samples of feeding stuffs were reported upon. Eight samples of milk of pure and cross-bred cows were also analysed.

Botanical Section. One sample of soil was analysed.

Entomological Section. One sample of sodium arsenate was examined.

Mycological Section. Two samples of fungicide were reported upon.

Indigo Research Section. Two samples of manures were analysed.

Cotton Specialist's Section. Forty samples of cotton seed were examined.

Sugar Bureau. Sixteen samples of sugarcane were analysed for the Secretary, Sugar Bureau.

Imperial Bacteriological Laboratory. Two samples of feeding stuff and three specimens of the stomach contents and livers of hill bulls were examined for the Director and First Bacteriologist, Muktesar.

C. The examination of the soils of the experimental plots in the Punjab Field was completed. The results were submitted by Dr. Harrison in December 1919 to the Committee appointed by the Board of Agriculture to review the permanent manurial and rotation experiments at Pusa. These experiments, which were started in 1908, were designed to find out the specific effect on soil fertility of the more important organic and chemical manures, alone and in various combinations, in a 2-year 4-course rotation. It was also sought to determine how far soil fertility is affected by growing in rotation, leguminous crops (1) removed from the land, (2) returned to the land in the shape of green manures. The results obtained are noted below.

The effect of applications of organic manures. Bulky organic manures have a very appreciable effect in increasing the total crop, but whereas with cereals the proportion of grain is materially increased, the reverse is the case with *rahar* (*Cajanus indicus*). The residual effect of rape cake is inappreciable on the second crop, although its effect on the crop to which it is applied is very marked. Rape cake is therefore not as effective as farmyard manure when the application is only once in a full cropping season.

The effect of mineral manures. Of the manurial constituents nitrogen, potash and phosphoric acid when applied alone, the last is the only one which gives a distinctly positive reaction in Pusa soil, but the combination of all three gives the best results to the crop to which it is applied. In the case of cereals the use of phosphoric acid increases the proportion of grain, but in the case of *rahar* all manures increase the proportion of green matter.

The effect of pulse crops in a rotation. It was noted that the benefit due to the inclusion of legumes in the rotation is positive so far as the yield of grain is concerned, but the increases obtained are not of great magnitude and there is practically no change in the weight of straw produced. In the case of *rahar*, the addition of a shallow-rooted legume to the rotation resulted in slight decrease.

The effect of green manures. The very definite depletion of the yield of *rahar* under the influence of green-manuring—even when in conjunction with superphosphate—is very remarkable, but it receives some confirmation from the observation recorded above that the introduction of a second leguminous crop led to a slight reduction of the yield. It would almost seem that as if the use of green manures in conjunction with a leguminous crop of the type of *rahar* were deleterious. It is desirable that this point should be tested more rigorously.

Regarding the cereal crops the returns are very definite and distinctly demonstrate the great benefit derived from green manures, even in purely cereal rotations. The introduction of a legume into the rotation gives only a comparatively small increased benefit. The outstanding feature is, however, the value of a combination of green manure and superphosphate.

V. Methods of analysis.

As recommended by the Chemists' Conference held in February 1919, an investigation of the methods of analysis of nitrogen and phosphoric acid in manures and fertilizers has been undertaken at Pusa. Ease of manipulation together with the period of time involved in the estimations is being taken into consideration along with the accuracy of the results obtained. The results obtained so far are recorded below.

Nitrogen. Kjeldahl's original method for the estimation of nitrogen, and the various modifications which have been proposed by different workers are being closely studied in this laboratory. It has been found that in Kjeldahl's method where no potassium sulphate is used, as well as in Gunning method where no copper sulphate or mercuric oxide is used, the time taken for boiling is long. In the methods where both copper sulphate and mercuric oxide are used to hasten the decomposition, the chances of oxidation are generally better, but it is still possible to get good results in some of the methods where only one of these is used.

The results of experiments so far tried indicate that rapid and accurate determinations may be made by the Kjeldahl-Gunning-Arnold, by Dyer's modification of Kjeldahl method and by the Gunning method as followed at Pusa.

Phosphoric acid. In all the methods tried the results obtained were compared with the figures obtained by the standard magnesia method. Mention may be made here of the methods which appear to be promising amongst those studied so far. The Pemberton-Kilgore method which is the one in use in this laboratory gives accurate figures. In the case of substances like superphosphate, ashes, etc., the phosphoric acid can also be quickly and fairly accurately determined by titration with standard alkali. The process consists essentially in rendering the solution of phosphate just neutral to methyl orange, adding an excess of neutral calcium chloride and then titrating until alkaline to phenol-phthalein. The volumetric estimation of phosphoric acid by silver nitrate solution has its limitations but it is capable of yielding good results under certain conditions.

VI. The retention of soluble phosphates in calcareous and non-calcareous soils.

The investigations in regard to the retention of phosphoric acid in calcareous and non-calcareous soils referred to in previous years' reports have now reached a stage which has enabled Dr. Harrison to submit them for publication. Consequently, a brief summary of the whole investigation is now given.

It used at first to be maintained that the retention of soluble phosphoric acid of superphosphate by the soil is simply due to the precipitation of phosphate of lime and later on of phosphates of iron and alumina. The precipitated phosphate being exceedingly finely divided and being thoroughly disseminated in the soil was accounted to provide a continuous supply of phosphoric acid to the roots of the growing plant. Evidence, however, soon accumulated which tended to show that this simple explanation did not

entirely agree with observed facts. The retention of phosphoric acid by the soil is not satisfactorily explained on the purely chemical grounds and, in all probability, the physical phenomenon of adsorption is an important factor. Adsorption is an instantaneous process, and consequently under conditions which obviate any possibility of the formation of insoluble compounds, may be looked upon as the factor governing the range of distribution of the phosphoric acid through the soil and the availability of the retained phosphate. On the other hand, the introduction of a secondary factor such as the formation of insoluble calcium phosphates must considerably modify the result, but the magnitude of this modification must depend largely upon the rapidity of the reaction concerned. It is conceivable that if, for instance, the rate of reaction between monocalcic phosphate—the chief constituent of superphosphate—and calcium carbonate is very rapid the range of distribution through a soil will be limited. Conversely, given a very slow rate of reaction the distribution will be wider. Evidence on this point is conflicting and it is impossible to formulate with any degree of certainty the probable course of events in highly calcareous soils such as are found in Bihar and other portions of the Gangetic alluvium. It therefore appeared desirable to investigate the predominating factors governing the distribution of soluble phosphates through calcareous and non-calcareous soils.

A study of the reaction between calcium carbonate and monocalcic phosphate showed that this is an extremely rapid process resulting in the formation of the comparatively insoluble dicalcic phosphate. The latter in turn slowly reacts with further quantities of calcium carbonate forming tricalcic phosphate. During the course of reaction carbon dioxide gas is produced which by increasing the number of calcium ions in solution reduces very materially the quantity of phosphoric acid formed in solution. Consequently, with calcareous soils the importance of cultural conditions which will tend to keep the CO_2 con-

tent of the soil gases at a minimum and thus permit of a greater concentration of the phosphoric acid in the soil solution is apparent.

From what has been noted above about the action of calcium carbonate on a solution of monocalcic phosphate it would appear probable that this reaction must play a prominent part in calcareous soils in retaining those forms of soluble phosphates which are capable of reacting, but that, on the other hand, the effect of this chemical retention would be at a minimum in non-calcareoue soils, and in these circumstances adsorption may be the limiting factor. It is of the utmost importance to determine which of these modes of retention is the predominant factor in the two types of soil for not only must the "availability" of the retained phosphoric acid be very dissimilar in the two cases, but the distribution through the mass of soil must also be very different.

With this object in view parallel series of experiments were carried out with a Pusa soil, representing highly calcareous soils, and a soil from Kalianpur which is almost devoid of lime. These showed that the phosphoric acid of superphosphate is mainly retained through adsorption in non-calcareous soils, whereas the retention is mainly due to other causes in the case of calcareous soils. Support to the conclusion that the retention of superphosphate by calcareous soils is due to chemical combination is lent by the behaviour of solutions of di- and tri-sodium phosphates with the type soils. In these latter cases no chemical reaction could be demonstrated between calcium carbonate and the sodium phosphates and the retention here obeys the adsorption laws.

The rapidity of the reaction between superphosphate and calcium carbonate lends very strong support to the hypothesis that this reaction must be the determining factor in the retention of phosphoric acid under conditions in which it can occur. If this is correct, then it would appear that when superphosphate is applied to a calcareous soil comparatively insoluble calcium phosphates are im-

mediately formed *in situ*, thus limiting the distribution of the phosphoric acid through the soil and causing the superphosphate to have a very localized value. On the other hand, in non-calcareous soils it would appear probable that the range of action would be wider and the distribution more uniform throughout the mass of the soil. To test this, the distribution of the phosphoric acid of different phosphates by percolation through columns of the type soils was studied. The results showed that the distribution of superphosphate through a non-calcareous soil is of an uniform type. The phosphoric acid penetrates to a considerable depth and consequently the effect of applications of superphosphate to such soils is widespread. On the other hand, the distribution of superphosphate in the case of calcareous soils is of a non-uniform type, the major portion of the phosphoric acid being held in the top layers of the soil. Consequently, the application of superphosphate to these soils has a very restricted effect and has therefore probably much less efficiency than equivalent amounts applied to soils of the opposite type. In proportion to the amount of superphosphate applied to the columns of soil, the soil solution of calcareous soils contains a much less concentration of phosphoric acid than in the case of non-calcareous soils. In the light of present knowledge this can only mean that the phosphoric acid retained is in a much more available form in the latter soils.

It has further been found that the presence of even 5 per cent. of calcium carbonate in a non-calcareous soil restricts the diffusion of the phosphoric acid of superphosphate. In fact, in such a case the phosphoric acid is practically completely retained in the top few inches. This shows that calcium carbonate is the determining agent.

On the other hand, it has been demonstrated that the distribution of the phosphoric acid of those soluble phosphates which are without action on calcium carbonate, through a column of soil is of an uniform type even in highly calcareous soils, and that the phosphoric acid penetrates to a considerable depth. It would, therefore, seem

very probable that such phosphates would be more efficacious than superphosphate in calcareous soils. This point is under investigation.

From the above it will be seen that the phosphate manuring of calcareous soils is obviously a very different problem to that of non-calcareous soils and requires special study.

VII. The windrowing of sugarcane.

An account of the work done at Peshawar on the windrowing of sugarcane has been submitted for publication. The investigation has further been continued in the laboratory during the past season. Samples of cane were cut into pieces and, after paraffining the cut ends, these were kept in desiccators. On examining these later on, it was found that the sucrose did not fall off but that, on the other hand, there was generally a slight increase of cane sugar. On wetting the canes which have been thus windrowed by desiccation there was a fall in sucrose content. It will be remembered that under field conditions at Peshawar there was noticed a similar increase of sucrose in the windrowed canes and that after a rainfall a deterioration of the canes set in. Canes are thus seen capable of being windrowed at Pusa where the temperature conditions are much higher than those obtaining at Peshawar. It appears that moisture is probably one of the important factors involved in these changes. In the laboratory, samples of canes were further examined under different conditions and the results obtained tend to show that the transformations of sucrose are caused by agencies which are present inside the cane and that enzymic activities are closely connected with these phenomena. This point is under further investigation.

VIII. The excretion of toxins from the roots of plants.

The water culture experiments detailed in the Pusa Memoir, Vol. II, No. 3, Botanical Series, "Note on a toxic excretion by the roots of plants" were supposed by the

author to support the view that the roots of crop plants excrete toxic substances. It may, however, be noted that these experiments were performed with ordinary well water and without any control tests, and that the method of experiment led to a considerable evaporation of water and a corresponding concentration of the dissolved salts. This being the case it was felt that the evidence was not conclusive and that a repetition of the experiments under more stringent conditions was desirable. With this object in view the same scheme of experiment was repeated with the exception that a synthetic nutrient solution was substituted for the well water, and "control tests" were introduced to check the results. The nutrient solution used was that of Knop.

A large number of wheat, *rahar* and gram seedlings were grown in this nutrient solution, and at the end of a certain period the solution was allowed to evaporate spontaneously until its volume was reduced to about one-eighth. The blanks were allowed to evaporate to one-third to one-fourth the original volume. Jars containing nutrient solution but bearing no seedlings were also treated in an identical manner, and constituted the "blanks." Seedlings were then introduced into these concentrated solutions, supposed to contain the excretions of plant roots, and the progress of crops grown in them was recorded. The results are noted below :—

Crops (of which progress is indicated)		Crops which had previously grown in the water				Distilled water
		Wheat	*Rahar*	Gram	Blank	
Gram	Period (in days) after which withering commenced	9	8	...	7	11
	Transpiration (in grams)	15·4	13·8	...	9·5	17·7
Rahar	Period (in days) after which withering commenced	15	21	21	17	39
	Transpiration (in grams)	15·0	22·9	17·5	21·5	32·3
Wheat	Period (in days) after which withering commenced	41	...	...	36	48
	Transpiration (in grams)	34·3	...	...	31·0	54·0
Total solids per 100 c.c. of water at the end of the experiment		0·269	0·154	0·226	0·382	nil

From the above table it is evident that, in general, the seedlings grown in "wheat," "gram," and "rahar" water throve better than in the "blank test" solution, and that seedlings grown in distilled water fared best. These observations led to the conclusion that the positive results obtained in the experiments recorded in the memoir were probably due to the concentration of the salts present in the well water and not to toxic excretions. This is confirmed by an examination of the figures for the "total solids" in the solutions. The concentration of "blank" water in which the seedlings grew the worst was the highest, whereas the best results were obtained in the distilled water. The results obtained from the other "waters" were intermediate in character and approximately proportionate to the concentration. In short, the present series of experiments point to the conclusion that increased concentration of any solution beyond a certain limit leads to a toxic effect by some or all of the component salts present in the solution. The strength of the solution in the original experiment recorded in the memoir works out approximately to 1·12 per cent., a concentration which no doubt will prove toxic to any plant. The presence of an alkaloid which the author inferred was the character of the excreted toxins could not be demonstrated in the present experiments, and consequently it is only possible to conclude that the effect which had been ascribed to toxic excretions, is in reality due to the high concentration of salts in the solution employed in the final stages of the experiment. An account of the present experiments which have been carried out by Mr. Mukerji has been submitted for publication in the "Agricultural Journal of India."

IX. Carbon dioxide in soil air.

Periodical determinations of carbon dioxide were made in the soil air of three plots in the Botanical Area. Of these the first plot was grassed down, the second was grassed down but was partially aerated by trenches, and

the third was kept surface-cultivated. The results are recorded below :—

Percentage of CO_2 in the soil gas from three different plots in the Botanical Area.

Date and the month when the soil gas was aspirated	Plot No. 1 grassed down	Plot No. 2 grassed down but partially aerated with trenches	Plot No. 3 surface cultivated	Rainfall in inches since the last analysis was made
13th, 14th and 17th January, 1919 .	0·444	0·312	0·269	...
20th and 21st February, 1919 . .	0·472	0·320	0·253	1·30
21st and 22nd March, 1919 . .	0·427	0·223	0·197	0·03
23rd and 24th April, 1919 . . .	0·454	0·262	0·203	1·36
16th and 17th May, 1919 . . .	0·271	0·257	0·133	0·57
17th and 18th June, 1919 . . .	0·341	0·274	0·249	1·27
17th and 18th July, 1919 . . .	1·540	1·090	0·304	10·08
25th and 26th August, 1919 . . .	1·590	0·836	0·401	8·68
19th and 20th September, 1919 . .	1·910	0·931	0·450	7·38
21st and 22nd October, 1919 . .	1·297	0·602	0·365	2·23
14th and 15th November, 1919 . .	0·853	0·456	0·261	...
22nd and 23rd December, 1919 . .	0·398	0·327	0·219	0·02
19th and 20th January, 1920 . .	0·342	0·250	0·186	0·02
24th and 25th February, 1920 . .	0·382	0·342	0·238	1·70
19th and 20th March, 1920 . .	0·457	0·383	0·230	1·00
16th and 17th April, 1920 . . .	0·367	0·321	0·222	0·11
19th and 20th May, 1920 . . .	0·385	0·315	0·236	0·32
22nd and 23rd June, 1920 . . .	0·544	0·524	0·275	2·21

It will be seen that the percentage of carbon dioxide in the soil air is highest in the grassed plot and lowest in the cultivated plot, the air in the soil of the trenched plot being intermediate in composition. During the first six months of the year 1919 the carbon dioxide in the air of the grassed plot was between 0·5 to 0·3 per cent., that in the trenched

and cultivated plots being 0·3 to 0·2 per cent. and 0·3 to 0·1 per cent. respectively. There was a sudden rise in the carbon dioxide in the months July to September. In the grassed plot it rose to 1·5 to 2 per cent., in the trenched plot to 1·0 to 0·9 per cent., and in the cultivated plot to 0·4 to 0·5 per cent. This rise seems to be connected with the rainfall and with the movements of the soil water level. From the month of October there began to occur a fall in the carbon dioxide content, this being 1·3 to 0·4, 0·6 to 0·3 and 0·4 to 0·2 respectively in the three plots. These rises and falls were most pronounced in the grassed plot and less so in the trenched plot. The variations were of the least magnitude in the cultivated plot. The figures obtained during the year 1920 agree very closely with those of the previous year.

X. Tobacco experiments.

Determinations of the dry matters of this season's tobacco have confirmed the observations noted in the previous years that the yield of leaves in the case of "topped plants" is as good or even better than that in the case of "spiked" plants; as regards stems, the yield in case of the "topped" is much higher than in that of "spiked" plants.

XI. Paddy manurial experiments.

A series of experiments with local paddy were carried out to compare the effect of ammonium sulphate used as a manure alone and also in combination with green manures. It was found however that—so long as phosphate manures were simultaneously applied—an increasing dose of nitrogen gave increased yields up to 160 pounds nitrogen to the area. Beyond that point there is a falling off and with 320 pounds the yields are little better than with no nitrogen at all. The tendency was for small doses of nitrogen to increase the proportion of straw to that of grain, but with 80—160 lb. to the acre the increase in grain was greater than that of straw and, consequently, the most economical application would appear to be between 80—160 pounds of nitrogen.

Green manure used alone gave an increased total crop of 65 per cent. but, notwithstanding this, when used in conjunction with ammonium sulphate it had no appreciable effect.

The employment of ammonium sulphate as a manure resulted in a considerable increase in the percentage of nitrogen found in the grain, and the increase was approximately proportional to the amount of nitrogen added as manure. The actual variation was 1·15 per cent. of nitrogen in the grain from the no-manured pots to 2·39 per cent. nitrogen in that from the pots manured at the rate of 320 pounds nitrogen per acre. This very interesting point is being subjected to further investigation.

XII. Programme of work for 1920-21.

Major subjects.

1. Continuation of the investigations into the amount and nature of drainage water from fallow and cropped land.

2. The influence of manurial treatment of the soil on the composition of crops.

3. The mode of action of phosphatic manures in calcareous and non-calcareous soils.

4. A laboratory study of the changes occurring in windrowed cane.

Minor subjects.

1. Checking the accuracy of certain methods of analysis in confirmation to the general scheme drawn up at the Conference of Agricultural Chemists.

2. A study of the conditions governing the formation of black alkali in soils irrigated by calcareous water.

XIII. Publications.

Harrison, W. H. . Report on Agricultural Chemistry, 1918-19, for the Board of Scientific Advice.

Harrison, W. H. . The gases of swamp rice soils, Part VI. *Mem. Dept. of Agri. in India, Chem. Ser.*, Vol. V. No. 8. (*In the press.*)

Harrison, W. H. and Das, S. The retention of soluble phosphates in calcareous and non-calcareous soils. *Mem. Dept. of Agri. in India, Chem. Ser.*, Vol. V, No. 9. (*In the press.*)

Harrison, W. H. and Sanyal, P. B. The effect of windrowing on the composition of sugarcane. *Mem. Dept. of Agri. in India, Chem. Ser.*, Vol. V, No. 10. (*In the press.*)

Mukerji, J. N. . The excretion of toxis from the roots of plants. *Agri. Jour. of India*, Vol. XV, Pt. 5. (*In the press.*)

REPORT OF THE IMPERIAL ECONOMIC BOTANIST.

(G. P. Hector, M.A., B.Sc.)

I. Introduction.

Mr. Howard held charge of the Section up till December, when he proceeded on 11 months' combined leave, accompanied by Mrs. Howard, Second Imperial Economic Botanist. I took over charge of the Section on 20th December and held charge for the remainder of the year.

In 1919, the hot-weather deputation of Mr. and Mrs. Howard to Quetta, for the purpose of developing the fruit industry of Baluchistan, terminated. The work has been handed over to the Local Administration.

The following are the main items of work which have been in progress.

II. Wheat.

In the Botanical Area, work on wheat during the past season has been confined to the growing of large areas of P 12, P 4 and P 6 as a nucleus of pure seed for distribution purposes, and to a trial of P 53, a new rust-resistant wheat produced by Mr. Howard by crossing on P 6, against P 12, to test its relative yielding capacity. The result of this test was as follows :—

No. of plot	Variety	Area	Actual outturn			Per acre outturn		
			m.	s.	ch.	m.	s.	ch.
1	P 12	0·09	1	22	8	17	14	0
2	P 53	0·18	3	12	8	18	16	0
3	P 12	0·09	1	30	8	19	18	0

As a result of a severe rain-storm in January, P 53 lodged very badly, while P 12 did not suffer so much. All plots had black rust moderately.

In October 1919, seeds of the new Pusa wheats Nos. 46, 47, 48, 50, 51, 52, 53, 54 were sent to Mr. Burt, Deputy Director of Agriculture, Cawnpore, and have been under trial the past season at the Cawnpore, Kalianpur and Shahjàhanpur farms.

Mr. Burt reports that as the areas were small and the experiment somewhat upset by two canal failures, the results are not sufficiently dependable to enable strict comparison with Pusa 12 to be made from the results of one year only. They indicate, however, taken in conjunction with the appearance of the standing crop, that several of the hybrids are very promising. Mr. Burt states that it seems likely all the wheats of the 50—54 series will be higher yielders than P 12. They possess stronger straw and hold their grain better.

Experiments were also conducted on P 12 to test the effect of varying irrigation and cultivation on yield and quality, but the results are not available for this report.

No large distribution of seed in bulk from outside sources has been made this season, but about 114 maunds of pure seed from the Botanical Area supply have been sent out to about 40 different applicants.

Spread of Pusa wheats. In the United Provinces, Mr. Burt reports that the systematic introduction of P 12 wheat in the Doab and Oudh portions of the Central Circle is being continued in co-operation with zemindars, Court of Wards estates and co-operative societies. Two District Boards have undertaken seed-storage schemes of considerable magnitude during the year, the main item in each case being P 12. In the Allahabad Division, a feature of the past year's work has been an increase in the number of cultivating zemindars growing considerable areas of this wheat. This is said to have materially assisted the seed-supply problem.

The introduction of P 4 in the canal-irrigated tracts of Bundelkhand is also being continued, and progress is only limited by the amount of seed which the staff can handle and the amount of pure seed available. A special simpli-

fied Taqavi procedure for the supply of P 4 seed in the Cawnpore Division has recently been approved by the Commissioner.

Mr. H. E. J. Peake, Solan Brewery, reports excellent progress from the Simla Hills, and the following Hill States are said to have introduced P 12 with success :—Keonthal State, Junga; Baghal State, Arki; Baghat State, Solor; Patiala State, Patiala; Sirmoor State, Nahan.

These States comprise the majority of the States in the Simla Hills, and with the exception of Patiala all the States speak most highly of this wheat. The acreage in Sirmoor is said to be roughly 600 acres, and the Chief Secretary of Sirmoor State reports that it is their intention to extend P 12 this coming year towards Dehra Dun. In two or three years there will probably be nothing but P 12 in the whole of Sirmoor. This result is largely due to the trouble and keen interest taken by Sardar Narain Singh, Chief Secretary. It is also reported that P 12 sold in the market for annas 10 more per maund than the local wheat.

Pusa wheats in Australia. With reference to the spread of Pusa wheats in Australia, the following occurs in the report of the judges of the Royal Jubilee Show held at Sydney, Australia, in March 1920 :

"A sample of the Indian wheat, Pusa 4, exhibited by Mr. W. H. Scholtz, of Gilgandra, is worthy of mention. It yielded a percentage of excellent colour flour of 53 quarts to the sack strength, which was the highest water absorption of all the flours tested in the competition."

In the exhibit of strong wheats, Mr. Scholtz again stood first with an exhibit of Pusa 4, an achievement for the Indian wheat, and in the class for 5 strong flour varieties, Mr. Scholtz also stood first, two of his five being P 4 and P 107.

III. Indigo.

Full details of the work on indigo carried on by the Imperial Economic Botanist at Pusa are being published as a Memoir. During the past season, work has been confined to a continuation of observations on plants grown

in drained and undrained lysimeters, to the monthly examination of root-development, and the continuation of work on seed-selection.

Lysimeter experiments. According to the investigations of the Howards, indigo-wilt is nothing more than the effect of waterlogging and consequent lack of aeration. When there is heavy and continued rainfall, the water-level rises and the soil becomes waterlogged, the air supply to the growing roots and nodules of the plants is cut off, and the roots, consequently, cannot thrive. Hence the new roots and nodules begin to die off below and wilt appears above.

Evidence of this has been obtained by growing indigo plants in cemented lysimeters, provided with drainage openings. In cases where the openings were closed, all the plants in the lysimeter got wilt, even when growing in soil which was rich in phosphate, and those with free drainage all escaped, even when they were growing in a soil poor in phosphate. Observations on these plants growing in lysimeters are being continued for the second year, and the effect of drainage on the growth and the health of plant is still under observation. Field observations have afforded further evidence. The first sign of wilt in the Pusa Botanical Area appeared last year (1919) in the third week of July, *i.e.*, when the water-level was highest. When the water-level went down, aeration was regained to some extent and the plants began to improve. The water-level rose again in the first week of September, and again wilt appeared.

Root-development. Systematic monthly examination of root systems is being continued. It is found that the nodule and new-root formation begins in April, but up to the break of the rains their formation is very slow. Soon afterwards, they begin to grow quickly. When the water-level begins to rise, new roots and nodules are formed towards the surface, and the older, lateral roots begin to change their direction, turning upwards, till by the end of July their tips reach very near the surface of the soil, and almost all new roots and nodules are found in the upper three inches. Weak plants which cannot form new roots

in the upper soil quickly get wilt. In all cases of wilted plants, nodules have been found to be absent and new roots very few.

As a result of Mr. Howard's investigations, five types of root-development have been recorded—

(*a*) Early bush type, with all laterals at right angles and near the surface.

(*b*) Early vertical type, with all laterals near the surface but pointing down.

(*c*) Late bush type, with laterals at right angles, both near the surface and extending to some depth.

(*d*) A similar type to (*c*), but with laterals pointing downwards.

(*e*) No side branches, but tap root only.

Type (*a*) has been found much less subject to wilt than the others, and in the 1919 root examinations every case of wilt examined was found associated with deep-rooting.

Seed selection. As mentioned in previous reports, Java indigo is not uniform, but consists of a mass of heterozygotes differing widely in habit and character. This is due to the cross-pollination which takes place, owing to which selection by pure lines is not possible, as plants do not set seed under bag, and a system of mass-selection has therefore to be resorted to. Some types are deep-rooted with long tap roots, others shallow-rooted with surface roots. The habits above ground differ in similar ways, some being much more branched than others. There are also differences in the maturity of plants. The object of the selection is to obtain early, surface-rooting, freely-branching plants, which will give good yields of both seed and leaf. A considerable amount of selection work has already been done, and some types are already being tested on an estate scale. Further selection work was started in 1917-18 and is still in progress. In that year plants were selected for their free-branching habit and high yield of seed and leaf, together with other desirable qualities, such as earliness and surface-rooting. Seed of these selected plants was sown in August 1918 in separate lines. From these, 100 desirable

plants were chosen and arranged (in 1918-19), according to yield of seed, outturn of green plant at first and second cut, and condition of growth at the time of the second cut. Finally, the best were kept for sowing in August 1919, and the process is being repeated. In this way it is hoped to bring the crop back to a type which will thrive on the soil conditions of Bihar, giving good yields of both seed and leaf, and showing a high power of resistance to wilt.

IV. Linseed.

For some years a large collection of Indian linseeds has been grown at Pusa, and a lot of work done on the pollination, fertilization and classification of this crop, with the object of selecting superior types. During the past season, the main facts with reference to pollination and fertilization have been verified and the classification of previous years has been checked. This work has been carried out by Maulvi Abdur Rahman Khan, Second Assistant. Out of 233 original kinds, 129 have been selected and are still under observation. These 129 have been grouped into 38 classes, arranged according to colour and size of seed, colour of flower and shape of petal.

The seeds vary from yellow to brown and are grouped into three main classes, *viz.*, (*a*) yellow, (*b*) fawn, and (*c*) brown. Each of these seed-classes is again sub-divided into small-seeded, medium, and bold, while again within these groups there are blue and white-flowered types.

Much attention has been paid to the pollination of this crop. The details of this have already been described by the Howards (*Mem. Dept. of Agr. India, Bot. Series*, X, No. 5, pp. 208-211, Dec. 1919). The flowers open in the early morning, the actual time depending on temperature and humidity. The anthers burst longitudinally when the flower is half open, and at this time stand away from the stigmas. Later, when the flower is full open and dehiscence of the anthers complete, they close in on the stigma and self-pollination is effected. In many cases it has been observed that twisting of the styles occurs after the anthers begin to

burst, and that this twisting helps to move round the burst anthers and thus bring the pollen-covered surface of the anthers into contact with the stigma. Cross-fertilization is rare, but by no means unknown, and necessitates the bagging of seed in all exact work.

From the results of this work it appears the Central Indian types, having a deep root system, do not form good seed in Bihar. Local types, having a shallow root system, thrive well and form good seed, but the seed is small and inferior. To improve the seed of Bihar linseed, it will probably be necessary to produce a new race by crossing between Bihar and Central India types. A type possessing a root system like the Bihar varieties and seed qualities like the Central India types is desirable.

V. Tobacco, Grams, Hibiscus, etc.

Tobacco. Work on tobacco was restricted to the growing of Mrs. Howard's selected types, for the maintenance of pure seed. Of these, 51 were *Nicotiana tabacum* and 20 *Nicotiana rustica.*

Besides these, over an acre of the selected type, No. 28, was grown for seed multiplication, in order to obtain a large supply to meet the ever increasing demand for this type. From 1·2 acres, 15 maunds 5 seers of seed were obtained, sufficient to grow approximately 95,000 acres. In previous years it has been found impossible to grow sufficient seed of this type, owing to the difficulties of preventing cross-pollination, as other types were being grown in the vicinity. This year it was possible to allow the flowers to pollinate freely and set seed right throughout the season, so that a heavy seed crop was obtained.

During the period under review approximately 2 maunds of seed, sufficient for about 12,000 acres, of this type have been sent out, the largest quantities to the Indian Leaf Tobacco Development Company, Dalsing Serai, and to Burma.

Grams. During the period under review, the following types of selected Pusa grams were sown for observation and

multiplication of pure seed. The types and yields obtained are shown in the statement.

Area in acre	Gram type	Actual outturn	Per acre outturn	REMARKS
		m. s.	m. s.	
0·26	17	2 36	11 6	
0·20	18	2 20	12 20	
0·31	18	2 36	9 14	
0·75	18	7 8	9 24	
0·37	23	3 28	10 24	
0·15	25	1 27	11 7	
0·26	6	0 8	0 31	Sown after indigo; germination very poor.

The season was a very unfavourable one, and the yields are low. Seeds of all these types are now being largely distributed, the quantity of seed available being quite insufficient to meet the demand. During the period, approximately 15 maunds of seed of types 6, 17, 18, 23, and 25 have been distributed.

Patwa (*Hibiscus cannabinus* L.). Eight selected types were grown in the season under review for maintaining pure seed. Type 3, a medium-early, tall, straight form, with little tendency to branch and of robust growth, has been found the most suitable for fibre production, and has been under distribution for some years. One acre was grown during the year for seed production, and yielded 3 maunds 29 seers, and some 10 seers of seed have been distributed.

Safflower. Twenty-four types (described in the *Mem., Botanical Series*, Vol. VII, No. 7) have again been grown during the year under report for observation and the maintenance of pure seed. Besides these, several new types, selected from seed procured locally and from Dacca, were also under study. These seem now fixed in character and have therefore been added to the already existing types. The Dacca types are spineless, and appear richer in dye

than the Bihar types, which are also all spinose, and for both reasons should be more valuable.

During the season, the crop of safflower was severely attacked by a fungus disease, identified by the Imperial Mycologist as *Rhizoctonia napi.* The first sign of disease appeared in the first week of January and the spread was continuous right through up to the seed-maturing stage. In the case of local Bihar types the attack was late and more pronounced, and consequently very little seed set in these types.

Yams. Eleven varieties of yams were received from the Straits Settlements last year and were sown with local yams for a comparative trial of yield and quality. The tubers received were very different in appearance from the common local yam, *suthni* (*Dioscorea fasiculata* Roxb.).

To test the quality, some tubers of each variety, after boiling, were given to local people, and two varieties, No. 288 and No. 290, were declared to be superior to the local *suthni*, and have again been sown for a further trial.

VI. Rice.

A considerable part of the time of the Officiating Imperial Economic Botanist has been spent in supervising work in Bengal on rice, in conjunction with the Acting Economic Botanist, Bengal. This work has, for its main object, the selection, and production by crossing, of high-yielding types, suitable for the various districts of the province, together with the study of the varietal and field characters of types and of their inheritance on crossing. In addition to the types already under distribution, the department now has two other high-yielding pure-line types of transplanted paddy, suitable for distribution in the eastern districts, while a new selection at Chinsurah promises to replace *Indrasail* (Dacca No. 1) and the local *Nagra*. The problem in West Bengal is briefly to reduce the duration of high-yielding types, such as *Indrasail*, without materially decreasing the yield. Owing to the prevalence of a short rainfall in the latter end of the season, the types selected for

East Bengal are rather late for the western districts, and a paddy which will stand a shorter rainfall is required. On good rainfall, *Indrasail* is a heavier yielder than *Nagra*, but *Nagra* flowers and ripens 7 to 10 days ahead of *Indrasail*, and in a season of short rainfall and in higher, drier situations *Nagra* is a safer paddy to grow. Crosses between the two are under observation, and it is hoped selections from these will be an improvement on either parent.

A large amount of work is being done on the inheritance of characters, particularly with reference to the combination of characters. These include such characters as earliness and lateness, size, shape, colour and consistency of grain, and various colour characters. Amongst coloured paddies, no fewer than 53 different colour combinations have been found with reference to the distribution of colour in leaf-sheath, nodes, glumes and stigma, and a number of reciprocal crosses between selected types of these are under observation.

Further work in progress includes a study of the transpiration of early and late types of *aus* and *aman* paddy, with a view to determine whether there are varietal differences in this respect, and ultimately of determining whether the transpiration ratio can be reduced by manuring or other cultural methods. Any method of economising water without reduction in yield would be of great value in Western Bengal.

VII. Jute.

In conjunction with the Fibre Expert, Bengal, a study of chlorosis in jute has been undertaken in the Botanical Area at Pusa. Chlorosis is prevalent in many varieties of jute throughout Bengal, particularly in the northern districts, and is responsible, where bad, for a reduction in yield of several maunds per acre. At first, it was supposed that a difference in root system was associated with chlorosis, healthy plants showing a strong development of surface roots, with little or no tap root, and chlorotic plants generally showing an absence of surface roots, and a tap

root which ultimately shows a tendency to turn upwards. Further observations, however, appear to show that this is an effect of the chlorosis, and not a cause. As the water-level rises and the soil becomes practically waterlogged to very near the surface in the rains, as in East Bengal, the healthy, well-nourished plants throw out more and more surface roots, till ultimately a bunch of surface roots is found close to the surface. The chlorotic plants, on the other hand, being enfeebled through their inability to synthesise carbohydrate, are unable to do this, and in consequence, in addition to being starved from above, are slowly asphyxiated from below. Finally, the tap root of such plants endeavours to turn upwards, away from the wet. A systematic examination of the roots is in progress with a view to determine this.

Cultures grown at Pusa seem to show that the chlorosis is undoubtedly hereditary, seedlings of a few days old showing signs of it. The main facts so far proved are :—

1. *Chlorotic* plants never breed pure, but always throw greens.
2. *Green* plants may (as opposed to *chlorotic*) breed practically pure, but generally throw chlorotics.
3. The percentage of chlorotics (whatever the parent is, green or chlorotic) is not constant. In the variety *Kakya Bombai*, in 1919, out of 42 plots, the percentage varied from 11 to 30, with an average of 21·5.
4. By constantly selecting chlorotics and breeding from these, a race of practically pure chlorotics can be produced, and by constantly selecting greens, a race of practically pure greens can be produced, but no absolutely pure race of either has yet been obtained. In chlorotic plots a few greens always appear, and in green plots a few chlorotics.

The facts tend to show that it is possibly a case of maternal inheritance, the disease being passed on through the cytoplasm of the egg-cell. This cannot be definitely

proved till the results of crosses between chlorotic and green plants are available. A number of crosses made in Dacca last season were unfortunately destroyed in the cyclone, but the work is being repeated this season both in Dacca and Pusa.

A form of chlorosis very similar to that in jute has been found to be prevalent in *rahar* (*Cajanus indicus*) in Pusa, and selections have been made for the purpose of further study. It is proposed to make further search amongst other crops. Chlorotic plants have been frequently noted in the species of *Phaseolus* cultivated in East Bengal, and it is possibly a fairly frequent phenomenon.

VIII. Programme and Publications.

Programme for 1920-21. Investigations will be continued on the following crops on the lines of previous years—wheat, indigo, tobacco, fibres, grams, oilseeds, fodder crops and fruit.

Publications. The following papers were published or written during the year :—

1. Report for 1918-19 on Economic Botany for the Board of Scientific Advice, by A. Howard.
2. Studies in the Pollination of Indian Crops, I, by A. Howard, G. L. C. Howard, and Abdur Rahman Khan. *Botanical Memoir*, Vol. X, No. 5, December 1919.
3. The "Spike" Disease of Peach Trees: An example of unbalanced Sap-circulation, by A. Howard. *The Indian Forester*, Vol. XLV, No. 12, December 1919.
4. Some Labour-saving Devices in Plant-breeding, by A. Howard and G. L. C. Howard. *Agri. Jour. India*, Vol. XV, No. 1.
5. The Improvement of Fruit Packing in India, by A. Howard and G. L. C. Howard. *Agri. Jour. India*, Vol. XV, No. 1.
6. Some Aspects of the Indigo Industry in Bihar. Part I. The Wilt Disease of Indigo. Part II. The factors underlying the seed production and growth of Java Indigo, by A. Howard and G. L. C. Howard, assisted by Abdur Rahman Khan and Chaudhari Ram Dhan Singh. *Botanical Memoir*, Vol. XI, No. 1. (*In the press.*)

REPORT OF THE IMPERIAL MYCOLOGIST.

(E. J. Butler, D.Sc., M.B., F.L.S.)

I. Charge and Establishment.

I held charge of the Section throughout the year, except for the period from 1st May to 17th June, 1920, when I was appointed sub. *pro-tempore* Agricultural Adviser to the Government of India and Director of the Agricultural Research Institute, Pusa. Mr. G. P. Hector, Officiating Imperial Economic Botanist, held charge during this period. The work as Joint Director was unusually heavy last year owing to the development of proposals for the expansion of the Agricultural Research Institute and the revision of pay of establishments due to changed conditions after the war, and left little time for mycological work. The Section further suffered by the absence of Mr. Dastur, Supernumerary Mycologist, on deputation to England from the end of August 1919, and of Dr. Shaw, Second Imperial Mycologist, on leave from 5th February, 1920.

Towards the end of the year I was appointed Director of the Imperial Bureau of Mycology in London, and leave shortly to take up this post, Mr. W. McRae, Government Mycologist, Madras, succeeding me as Imperial Mycologist.

Mr. M. Mitra, M.Sc., who entered the Section as a private student last year, was appointed First Assistant from 1st April, 1920.

II. Training.

In addition to Mr. M. Mitra, mentioned above, Pandit S. D. Joshi, a private student from the United Provinces, continued his post-graduate course and was granted a stipend by his Local Government. Mr. T. Padmanabha Pillai, Mycologist, Travancore State, worked at laboratory methods during a period of one month from 5th February, 1920.

III. Diseases of Plants.

(1) Black band disease of jute. The research work on this disease was continued by Dr. Shaw. In Bihar, in 1919, the state of the jute crop was similar to that in 1918. A considerable portion of the seed-crop had, however, been sown as late as June and this was invariably clean and healthy. This confirms the observations made last year from the infection of the crop all over Bihar that the late sown crop is relatively immune. In the more early sown areas the crop was only slightly diseased and not to an extent which would seriously diminish the yield. The condition of the crop on the Dacca Farm by no means agreed with that in the previous season. Both the green and the red-stemmed varieties of *Corchorus olitorius* were attacked. The incidence of the disease was not heavy and varied considerably in different fields on the farm. The greatest damage seen in any one area was probably about ten per cent. The red-stemmed *C. capsularis* was also attacked. These observations are quite sufficient to show that neither the red-stemmed varieties of *C. capsularis* nor of *C. olitorius* were resistant to the disease. At Chinsurah Farm where the jute consisted of the same red and green varieties as at Dacca, the crop was very fine, averaging about 14 feet in height, and there was not a single case of black band. At Rangpur the crops of both *C. olitorius* and *C. capsularis* were infected. The disease, however, only reached an appreciable degree when the plants were of a certain size.

Infection experiments carried out both on plants in pots and on plants in the field showed that though red varieties of *C. capsularis* and *C. olitorius* are by no means immune yet under the conditions of the experiments they seem less susceptible. A large number of experiments carried out on green *C. capsularis* showed that the number of successful infections depended on the humidity of the air at the time of experiment and the exact determination of the conditions is a point for further investigation.

The field experiments carried out in 1918 with the object of throwing light on the conditions affecting the spread of the disease were repeated.

1. Two plots (A and C) were sown with seed of green-stemmed jute about 5th March, the former with treated and the latter with untreated seed. The land had carried jute which was slightly drained the previous season but had not been under jute previously for 25 years. *D. Corchori* was practically absent in both plots; only some 3 or 4 cases could be seen.
2. In similar plots (B and D) a crop of *C. olitorius* and of red-stemmed *C. capsularis* also remained free from the disease.
3. Two plots (E and F), each about $\frac{1}{4}$ acre, situated in a portion of the field in which jute had some disease the previous year and was particularly bad the year before, were sown with seed of green-stemmed jute. The seed was steeped in a solution of copper sulphate. Germination was scanty and both plots were resown on 4th July after the commencement of the rains, and gave a crop of typical late sown jute, short in height and thin in stem. In both plots the number of stems infected with *D. Corchori* was negligible, only about 12 cases could be found when the crop was cut early in November.
4. Of two plots (H and K) about $\frac{1}{3}$ of each plot was sown on 5th March with a red-stemmed and the remainder with a green-stemmed variety of *C. capsularis.* These plots were situated in the land which had carried the diseased jute in 1918. Both the varieties of seed sown had been steeped in 2 per cent. copper sulphate. Plot H carried a very scanty crop and had 31 cases of *D. Corchori* among the green-stemmed and only 6 cases in the red-stemmed variety. In plot K the crop was much thicker, both germination and growth having been better than in plot H. In plot K there were 190 cases of *D. Corchori* among the green-stemmed and 34 cases in the red-stemmed variety.

5. Plots (M and N), each about $\frac{1}{4}$ acre, were selected in good land which had never carried jute before. Plot M was sown on 5th March with seed of green-stemmed variety which had been treated by steeping in copper sulphate solution, and plot N was sown on the same date with seed which had not been so treated. Both plots gave an excellent crop of jute, 9—11 feet in height. In both plots nearly the same number of stems were diseased owing to *D. Corchori*—76 stems in Plot M and 56 in Plot N.

As a result of these field experiments, particularly from a consideration of the last two plots, it cannot be said that seed steeping in copper sulphate has any influence on the severity of the disease, and, therefore, as mentioned above, the dissemination of the disease cannot take place to any appreciable extent through spores of *D. Corchori* mingled with the jute seed. The percentage of disease was also not to any extent greater in those plots which had been under jute for two or more successive seasons. Steeping the seed may then be discontinued.

An account of the work done on this disease during the last three years is now in the press as a Memoir.

(2) Fruit work in Kumaon. The season's practical work for 1919 was completed in July. The chief diseases dealt with were apple mildew (*Podosphæra*), which most nearly approaches epidemic conditions in these orchards, branch blister and apple cracking due to *Coniothecium chomatosporum*, fly speck and sooty blotch (*Leptothyrium Pomi*), and peach leaf curl (*Exoascus deformans*).

The apple mildew spraying series included a test of home-made lime sulphur, Berger's lime sulphur, and Burgundy mixture, lead arsenate being added in each case. The trees stood even the " winter " strength of lime sulphur successfully and the experiments showed that an application of this fungicide made at the proper time will largely control the disease. Berger's mixture proved very satisfactory and simple to use. Further experiments with iron sulphide

are, however, required before deciding on lime sulphur as the routine treatment.

For the *Coniothyrium* disease the same sprays were used. In general the superiority of the fruit on the sprayed rows was very marked. The home-made lime sulphur and Berger's mixture both gave good results and did no damage to the trees. Burgundy, however, caused so much damage to fruit and leaves as to be largely a failure. This bears out recent work in English orchards with this mixture.

There was little *Leptothyrium* present but the trees sprayed with lime sulphur and Burgundy had certainly less than the others. Burgundy injury was again marked. Peach leaf curl was entirely controlled by all three sprays.

The variation between different varieties in susceptibility to disease as well as in resistance to Burgundy injury is so marked that it is useless to expect comparative results unless the tests are made on the one variety. Northern Spy is so susceptible to mildew that it is being discarded on at least one estate. King of the Pippin was immune to *Coniothecium.* Burgundy injury was very bad on Cox Orange Pippin and the leaves were scorched on Esopus Spitz, while King of the Pippin was quite free from it.

I visited Ramgarh in October with Dr. Shaw and discussed future work on the spot. The proprietors of the Allen Orchard are kindly placing at our disposal a small building for mycological work. Owing to Dr. Shaw's absence no new experiments have been carried out in the 1920 season.

(3) Cereal diseases. It has long been apparent to mycologists in India that there is a large group of parasites belonging to *Fusarium*, *Helminthosporium* and allied genera which attack cereals throughout the country. Some of these, such as the stripe disease of barley, are well known in other countries, others appear to be peculiar to India or at least have not been previously described. Mr. M. Mitra took up the study of the species allied to *Helminthosporium* and has made considerable progress in this enquiry, which is likely to extend over several years.

Species of *Helminthosporium* were found commonly attacking maize, *jowar* (*Andropogon Sorghum*), *bajra* (*Pennisetum typhoideum*), rice, wheat, oats, barley, and sugarcane. In every case the chief attack is on the leaves, and excepting the stripe disease of barley the symptoms are on the whole very similar.

The parasite concerned was isolated from each of the above hosts and grown in pure culture for comparative study. Wheat was found to have a considerable range of forms on it in different parts of India. They appear to be related to *H. teres* Sacc. On rice the common species appears to be *H. Oryzæ* Hori, previously described from Japan. *H. turcicum* Pass. occurs on maize and *jowar* but freely grows also on wheat, oats, barley, and sugarcane. It does not attack *bajra* and only rarely rice. The species on sugarcane and rice attack all the hosts on which they have been tried whereas the wheat and barley species give reciprocal successful results. Further work on these lines is being done.

An allied genus, *Acrothecium*, is parasitic on several of the *Gramineæ* and one species attacks *bajra* at Pusa somewhat severely. It is a new species, which has been named *Acrothecium Penniseti*. The attack is on leaves, leaf-sheaths and ears, the leaf-form being the commonest but the ear attack probably doing most damage. The spikelets are attacked in clusters and the grain aborted. The attack is, as with so many other fungus diseases at Pusa, closely dependent on the atmospheric humidity.

The parasite has been isolated and studied in artificial culture by Mr. Mitra who has written a detailed account of it, now in the press as a Memoir. It is a vigorous parasite, with general points of similarity to other parasites of allied genera. It can attack maize ears but not the leaves; *jowar* is immune.

A second species, *Acrothecium lunatum* Wakker, is common at Pusa on maize and *jowar*, as well as on several wild grasses. It appears to do a good deal of injury to the male inflorescence of the former, where it is sometimes

associated with *Acrothecium falcatum* Tehon, but it is only a weak parasite on *jowar*. It is capable of attacking young leaves of *bajra* to some extent. Another form is found on rice. All these are being studied in pure culture.

Last season we received a number of reports and specimens of disease in wheat with the general symptoms of the foot rot disease which has attracted so much attention in the United States in recent years. As in that country a group of fungi seems to be responsible. The three fungi so far found in India are *Rhizoctonia destruens*, a *Pythium* of the *gracile* group, and a *Fusarium*. Of these the last is the most destructive, the other two being responsible in a limited number of cases only. All three fungi were isolated in pure culture by Mr. L. S. Subramaniam and successful inoculations were obtained with them on wheat grown at Pusa.

(4) Pythium disease of ginger and other crops. A Memoir describing fully this disease was published by Mr. L. S. Subramaniam during the year. As the work was summarized in last year's report it need not be further referred to here.

(5) Potato storage rots. Considerable attention has been given to the study of the means of preventing rotting of potato tubers during the hot weather and rains. Complaints of heavy losses from this cause leading to an excessive price of "seed" tubers at planting time, have become very frequent of late. A series of experiments was conducted at Sialkot in collaboration with the Punjab Department of Agriculture.

In storing potato tubers a two-storeyed well-ventilated house was selected and fumigated with sulphur vapour. Two sorts of tubers were selected: (*a*) from fields where potatoes were grown as ordinary routine crop, (*b*) from fields where potatoes were grown for the first time. The selected potato tubers were then put into sterile gunny sacks and fumigated with petrol vapour for 24 hours. Some of these fumigated potatoes were

stored (1) in dry sand, (2) in sacks loosely packed, and (3) on racks made of wooden battens. The rest of the fumigated potatoes were treated in corrosive sublimate solution (1 in 2,000) for 1 hour and afterwards taken out and dried and were stored exactly in the above manner. The experiment lasted during May and June 1919. The year being exceptionally trying on account of the excessive heat, potatoes started rotting very soon and in every case the bulk of the potatoes became rotten.

These results bear out the conclusion previously come to that the rot is primarily a result of excessive temperature and that it will be difficult, if not impossible, to check unless some form of cool storage can be devised. The natural suggestion is storage in the hills (at present a large proportion of the plains crop is from hill-grown seed and it should be possible to develop this by improving transport facilities and cheapening freight) but the alter-
natural suggestion is storage in the hills (at present a
Further work is required so as to get a more exact knowledge of the temperature limits at which storage may be expected to pay.

(6) Root rot of cotton. The writer visited Lyallpur in October 1919, to make a further attempt at diagnosing the cause of this disease. Previous efforts at Lyallpur and Hansi had been unsuccessful, the causes then assigned not standing the test of more exact observations and experiments. The conclusion arrived at on this last visit is that the disease is a non-parasitic one which is associated with some unknown soil condition. Further work will probably have to be taken from another side than the mycological. The disease occurs sporadically through most of Northern and Western India.

IV. Systematic work.

A good deal of progress was made in the preparation of a fungus flora of India, so far as the materials at present exist. The total number of recorded species is probably under 2,000 which is certainly not one-fourth of those that

exist. It is hoped to continue this work as opportunity permits.

An interesting paper has recently been published in the Philippines which gives evidence to support the view that the bud rot of coconuts is caused by the same fungus that causes canker of rubber and cacao and is usually known as *Phytophthora Faberi* Maublanc. If this is correct and the cause of bud rot in the Philippines is the same as in India this fungus will rank as one of the most destructive known. Its Indian name, *Phytophthora palmivora,* has priority over that given above.

V. Programme of work for 1920-21.

(1) *Research work.* New diseases of Indian crops that come to the notice of the Section will be investigated as opportunity permits, but the following diseases will receive special attention and will constitute main lines of investigation :—

(*a*) Black band of jute.
(*b*) Chilli diseases.
(*c*) *Fusarium* wilts, especially in relation to soil and manurial conditions.
(*d*) Sclerotial diseases of jute, sugarcane, paddy, and Rangoon bean.
(*e*) Orchard diseases.

Minor investigations will include the study of some fruit anthracnose, *Orobanche* on tobacco, root rot of cotton, sugarcane smut, *sâl* root rot, and *Pythium* disease of papaya, ginger and tobacco.

(2) *Systematic work.* It is hoped to resume this with the facilities provided by the proposed Imperial Bureau of Mycology in London. Steps will be taken to supply the Bureau with representative collections from India. The preparation of a list of Indian fungi will be continued.

(3) *Training.* This will be continued on the lines indicated in the prospectus.

(4) *Routine work.* Advice and assistance will be given to Provincial Departments of Agriculture and other Departments and to the general public.

VI. Publications.

Butler, E. J. . . Report on Mycology, 1918-19, for the Board of Scientific Advice.

Subramaniam, L. S. . A *Pythium* Disease of Ginger, Tobacco and Papaya. *Mem. Dept. of Agri. in India, Bot. Ser.*, Vol. X, No. 4, December 1919.

Shaw, F. J. F. . Studies in Diseases of the Jute Plant. (1) *Diplodia Corchori* Syd. *Mem. Dept. of Agri. in India, Bot. Ser.*, Vol. XI, No. 2. (*In the press.*)

Mitra, M. . . Morphology and Parasitism of *Acrothecium Penniseti* nov. spec. (A New Disease of *Pennisetum typhoideum* Rich.) *Mem. Dept. of Agri. in India, Bot. Ser.*, Vol. XI, No. 3. (*In the press.*)

REPORT OF THE IMPERIAL ENTOMOLOGIST.

(T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S.)

I. Administration.

The Imperial Entomologist held charge of the Section throughout the year ended 30th June, 1920. The services of Mr. M. Afzal Husain, M.Sc., Supernumerary Entomologist, were transferred to the Punjab Department of Agriculture from 16th September, 1919, since which date the post of Supernumerary Entomologist has remained vacant. Mr. G. R. Dutt, B.A., was appointed Personal Assistant to the Imperial Entomologist from 1st May, 1920.

II. Training.

Mr. G. D. Austin, a student deputed by the Ceylon Department of Agriculture, was received for training on 1st June, 1919, and completed the ordinary course on 31st March, 1920, but has been given an extension up to September 1920.

Three students completed a short course in sericulture and two were under instruction at the end of the year. Two students sent from the Agricultural College at Sabour were also given instruction not amounting to a regular course.

III. Insect Pests.

Cotton. The species of *Acrocercops* referred to and figured in last year's Report has since been named by Mr. E. Meyrick as *A. zygonoma*, n. sp.

The question of determining the relative immunity of varieties of cotton was continued. Germination of the plants was very satisfactory but at the close of the year the experimental cotton plants suffered from drought and heat,

the maximum shade temperature reaching as high as 112·3°F. The ground soon lost moisture and as a result the plants did not boll well; indeed, in the case of some varieties of cotton, there were no bolls at all to continue the countings. *Sylepta derogata*, together with *Phenacoccus hirsutus* and *Ph. corymbatus*, appeared and did considerable damage to certain varieties of cotton. During the year *Hibiscus abelmoschus* continued to be a better trap-crop for Cotton Bollworms (*Earias*) than either *bhindi* (*Hibiscus esculentus*) or hollyhock, and as in previous years a larger number of bollworms and of *Microbracon lefroyi* were found in the pods of *H. abelmoschus*. A survey of alternative foodplants of bollworms was made and is being continued. *Microbracon lefroyi* continued to be the most prominent parasite of *Earias*.

Rice. Work on the borer pests of rice has been continued in the neighbourhood of Pusa and confirmed the conclusion arrived at in last year's Report that on the average *in the Pusa district* these borers cause a relatively small amount of damage, amounting to about 4 per cent. In order to get an idea of their activities in some of the other rice-growing districts in Bengal and Bihar, the rice-stubbles of the following places were examined in December 1919.

At Chinsurah, stubbles examined in and around the Farm showed about 13·5 per cent. damage by borers. The actual damage to the crop (for reasons explained in the preliminary paper on Borers) would be less than this. In about 800 stubbles examined the following insects (larva, pupa or empty pupa-case) were obtained :—

Schœnobius bipunctifer	5
Chilo simplex	1
Chilo oryzæ	1

At Midnapur, stubbles collected from the neighbourhood of the town showed about 5·4 per cent. damage by borers. From about 500 stubbles examined the following insects were obtained :—

Schœnobius bipunctifer	7
Chilo simplex	1

At Bankura, stubbles collected from the neighbourhood of the town as well as from the villages in the interior showed about 22 per cent. infestation by borers. In about 1,000 stubbles examined the following were found :—

Schœnobius bipunctifer	12
Chilo simplex	9

At Cuttack, stubbles collected from all over the Farm exhibited only 9 per cent. damage by borers. From about 900 stubbles the following were obtained :—

Schœnobius bipunctifer	3
Chilo simplex	3
Chilo oryzæ	5
Sesamia inferens	3

From many of the experimental plots on the Cuttack Farm the crop was not yet harvested and some of these plots (each 1/5th acre in area) showed an unusually high proportion of dry ears. For instance, in two plots, one of a variety known as *khura* and the other of *kukrajota*, the number of dry ears was as high as 20 per cent., whilst in neighbouring plots under the same varieties of paddy the damage was much less than half that in the two plots mentioned. From the *khura* plot referred to 100 affected plants were pulled out from all over it and of these 40 were not damaged by insects whilst the remaining 60 exhibited damage by borers, of which the following were found :—

Schœnobius bipunctifer	30
Chilo simplex	8
Sesamia inferens	2

Out of 100 affected plants similarly picked from the *kukrajota* plot, no less than 92 were found damaged by borers and the following borer larvæ were obtained from them, *viz.* :—

Schœnobius bipunctifer	30
Chilo simplex	38
Chilo oryzæ	2
Sesamia inferens	1

There was no apparent reason why so many insects should have been concentrated in individual plots in this manner. The larvæ of *Chilo simplex* were observed to occur plentifully in the stems of *Coix lachryma-jobi* var. *aquatica*, which was growing as a weed all over the Farm and amongst the rice-plots, but all these experimental plots of rice-plants seemed equally subject to their influence. The concentration of the borers in individual plots seems therefore difficult to explain unless it was due to lateness of the crop.

From the above facts it would appear that *Schœnobius bipunctifer* and *Chilo simplex*, the former especially, are more important than other borers in rice. The combined effects of damage by borers in rice, however, in Bihar and possibly in Bengal, does not seem to amount to very serious proportions although even a loss of 4 or 5 per cent. in the case of an extensive crop such as rice becomes a noteworthy sum when expressed in money value. In the case of other parts of India, notably Madras and Bombay, the damage to rice by borers appears to be much greater, so far as we have definite figures, but it would be very desirable to obtain more exact information. Even taking the annual loss by borers at only 5 per cent. for the whole of India we find the annual loss to be approximately four thousand seven hundred millions of pounds of rice annually, and this figure may probably be at least doubled when we consider the total losses due to all rice-pests in India.

The Halticine Chrysomelid beetle (C. S. 2043), mentioned in last year's report, has been observed to occur largely on *china* (*Panicum miliaceum*). It is incapable of injuring plants standing in water but may cause some damage to dry-land paddy and millets.

Sugarcane. Work was continued on the borers of sugarcane and other cereals and also on other agents of damage to these crops which produce effects similar to those caused by the borers. The results obtained up to February 1919 have been incorporated in a paper by the present writer

and Mr. C. C. Ghosh, read at the Third Entomological Meeting, and which is still in the press. Since then considerable further information has been collected and brief notes on the more important points only can be given here; it is intended to write up these further results more fully in a separate paper.

As ascertained by observations extending over the last four years at Pusa, the principal damage to the sugarcane crop occurs in the early stages of its growth in April, May and June, when the climatic conditions at Pusa are characterized by high temperature, very low humidity (at least for the earlier portion of this period) and scantiness or absence of rainfall. The incidence of attack by insect pests is apparently correlated with climatic conditions. Favourable climatic conditions, enabling the crop to grow rapidly, have a great effect in controlling the activities of the pests, the crop in such cases easily outgrowing their attack. But with unfavourable climatic conditions, especially drought and want of moisture in the soil (and it must be remembered that sugarcane is not grown as an irrigated crop in these parts), the insects get the upper hand and owing to want of growth and tillering on the part of the plants the loss caused by their attack is not compensated for, the result being that the percentage of damage becomes very high. In 1920 the sugarcane was planted as usual about the middle of February but, in contrast to previous years, this was done after irrigating the land in order to secure proper moisture. No further irrigation was done and there was no rain worth mentioning until the middle of June. In April the damage in some of the thick canes at Pusa was as high as ten per cent., whilst at Coimbatore and Hebbal (Mysore) similar canes, although planted about the same time as but far more advanced in growth than the canes at Pusa, hardly exhibited any damage except a few occasional dead-hearts here and there. The sugarcanes at Manjri, planted earlier and grown under irrigation, were certainly not as good as the Coimbatore and Hebbal canes either in growth or as regards infestation by borers. The damage about this time

in *juar* (*Andropogon Sorghum*) and maize at Pusa was less than 0·5 per cent.

The correlation between damage to cane by borers (and similar agents) and climatic conditions seems to hold good in the case of all varieties of cane, thick as well as thin, but thin varieties show a greater immunity than thick ones. This will be evident from the following figures showing the percentage of damage in a few varieties of canes grown at Pusa this year :—

VARIETY		Date	Percentage damage	Date	Percentage damage	Date	Percentage damage	Date	Percentage damage	Date	Percentage damage
Name	Type										
Reora	Very thin	29-III	2·0	7-IV	1·3	26-IV	4·3	14-15-IV	4·7	11-19-VI	13·2
Maneria	Medium	..		8-IV	3·1	27-IV	10·3	13-V	12·5	5-VI	18·1
Purple Mauritius.	Thick	..		7-IV	5·8	27-IV	10·9	13-V	24·2	9-VI	37·2
Sathi 131 (experimental plot)	Thick	29-III	1·4	8-IV	1·1	25-IV*	9·9	11-12-V	12·4	20-22-VI	29·3
Sathi 131 (Farm plot)	Thick	..		7-IV	2·0	27-IV	9·3	13-V	20·5	7-VI	25·4

So far as germination was concerned, both the plots of Sathi 131 were very good and ahead of the other varieties, but this advantage was only maintained so long as the soil retained moisture from the irrigation done at the time of planting, and when overtaken by the drought these plots collapsed. All the affected shoots in the experimental plot of Sathi 131 were cut out on 25th April but the subsequent state of infestation shows clearly that this treatment was of no avail to reduce the percentage of attack.

Thin varieties of cane also seem more resistant to drought. In the first week of June the plot of Reora pre-

* All the affected plants were cut out with pruning scissors above the level of the ground so as to cause the least disturbance to the plants.

sented the greenest look of all the varieties, thick as well as thin. Next to this came the following in order of their drought-resisting qualities, so far as could be judged by the eye, Java 36, CO 210, Kussur, Tobe Manjet, CO 213 and CO 214, CO 204, CO 205 and other varieties of thin canes. All the thick varieties, including Sathi 131, Purple Mauritius and D 99 American, exhibited a scorched yellow appearance and in all these plots dead-hearts and dry shoots were prominent. Damage by borers and similar agents increased with the decrease in drought-resisting quality of the different varieties. The first heavy shower of rain fell on 18th June and was followed by other showers. By the end of the year under report (30th June) all the thin varieties had made good progress, but in the case of the thick varieties progress was extremely slow and it seemed that they would take a long time to recover from the effects of the drought. The above facts indicate the suitability of particular varieties of sugarcane to particular areas according to differences in local climatic conditions. Severity or otherwise of attack by borers seems to be intimately connected with this fact. Extended observations over different parts of India are required to throw light on this point and to enable us to arrive at definite conclusions.

Another point which requires similar extended observation is the pest-resisting qualities of different varieties of sugarcane. As a rule, thin varieties seem to be more resistant than thick varieties, but individual varieties, both of thick and thin canes, show different degrees of immunity. At Cuttack in December 1919, Minzo, a thin variety, had all the principal pests, *viz.*, *Scirpophaga xanthogastrella*, *Diatræa auricilia* and *D. venosata*, whilst Sathi, another thin variety, was practically free. Observations made about this time at Pusa, Cuttack and Chinsurah indicated a greater liability to fungal diseases on the part of Purple Mauritius than in the case of other thick varieties. A variety known as B. 3412 was observed to be very badly affected by smut at Chinsurah, whilst all other varieties growing there were completely free from this disease.

A third point which requires working out is the effect of the presence or absence of alternative foodplants. Instances have been given in the preliminary paper on Cane-borers of such effect in the cases of *Scirpophaga* and the Noctuid larva (C. S. 1666) in sugarcane and of *Chilo simplex* in rice. A notable instance which came under observation this year was the occurrence of *Diatræa venosata* as a regular pest in sugarcane at Cuttack, where no *juar* (*Andropogon Sorghum*) is grown and hardly any *Saccharum spontaneum* is present. At Pusa *D. venosata* occurs very commonly in *S. spontaneum* and in *juar* but rarely in sugarcane.

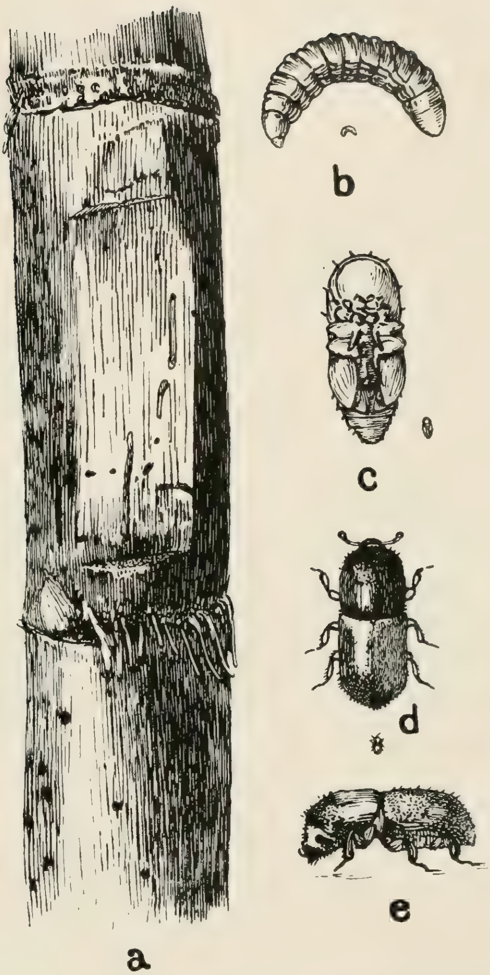
As a first step in dealing with the control of the borer pests of sugarcane we must take into consideration (1) the suitability or otherwise of the cane itself to the climatic conditions of the locality where it is grown, (2) the habits of the cane, especially its capacity for tillering during the early stages of its growth, as varieties which tiller well show much greater immunity than those in which tillering is poor, (3) the drought-resisting qualities of the canes, especially in the case of tracts where irrigation is not practised, (4) the natural immunity of the canes against pests and diseases, (5) the effect of the presence and absence of alternative foodplants of the different borers, as well as (6) the discrimination and life-histories (in the fullest sense of the word) of the borers themselves. All the above points are not applicable to any one particular locality, as conditions vary locally, but they clearly indicate the need for a whole-time worker, to devote his attention to sugarcane pests only. In order to arrive at successful results in the control of these pests he should include the whole of India within the sphere of his observation and experiment. In my suggestions for expansion of entomological work in India I have already pointed out the necessity for one whole-time expert to work at the question of borers and, when it is realized that a loss of ten per cent. of this crop (and this is probably not an excessive figure for India as a whole) means an annual loss of about three hundred millions of

rupees, it will probably be conceded that there is ample justification for an increase of staff to take up this work.

In the course of the last four years during which especial attention has been paid to the insect pests of sugarcane, the Scolytid borer, *Xyleborus perforans*, Woll (Plate IV), has only been observed once, in December 1919, in a variety of cane called B. 147, which was growing on the Chinsurah Farm. This beetle came into prominence over thirty years ago in connection with the destruction of beer-casks shipped to India and was investigated by W. F. H. Blandford, who considered *X. affinis*, attacking sugarcane in the West Indies, as a variety of *X. perforans*. In 1900 a *Xyleborus* was reported as boring sugarcane in Bengal and was considered to be either identical with, or closely allied to, *X. perforans*. In 1892 this beetle formed the subject-matter of a warning letter issued by the Revenue and Agriculture Department of the Government of India, which stated that this pest, notorious in the West Indies as a pest of sugarcane, had already been introduced into India and therefore advised the adoption of measures against its spread. Its occurrence on the Chinsurah Farm, where it was found breeding in three fully-grown canes growing in a clump, the canes being practically dry and showing characteristic holes emitting dust in their basal joints, indicates that this shot-hole borer may perhaps prove to be an occasional pest of cane, possibly more frequently than has been noted by us. In *Indian Museum Notes*, Vol. V, p. 74, it is recorded as having been found in cane in numerous districts in Bihar and Bengal. *X. perforans* is widely distributed in India and Burma and has been recorded as boring in *sal* (*Shorea robusta*), *Anogeissus latifolia* and *Areca catechu*.

Mention was made in last year's Report of three species of Dynastine beetles which occurred on the Kamrup Sugarcane Farm in April-May 1919, *viz.*, *Alissonotum impressicolle* (Plates V and VI), *A. piceum*, and *Heteronychus sublævis*. Attempts were made during the year to work out their full life-histories in the Pusa Insectary with

PLATE IV.



Xyleborus perforans (C. S. 1970).

a, Affected sugarcane stem ; a slice cut off from a part to show tunnels.

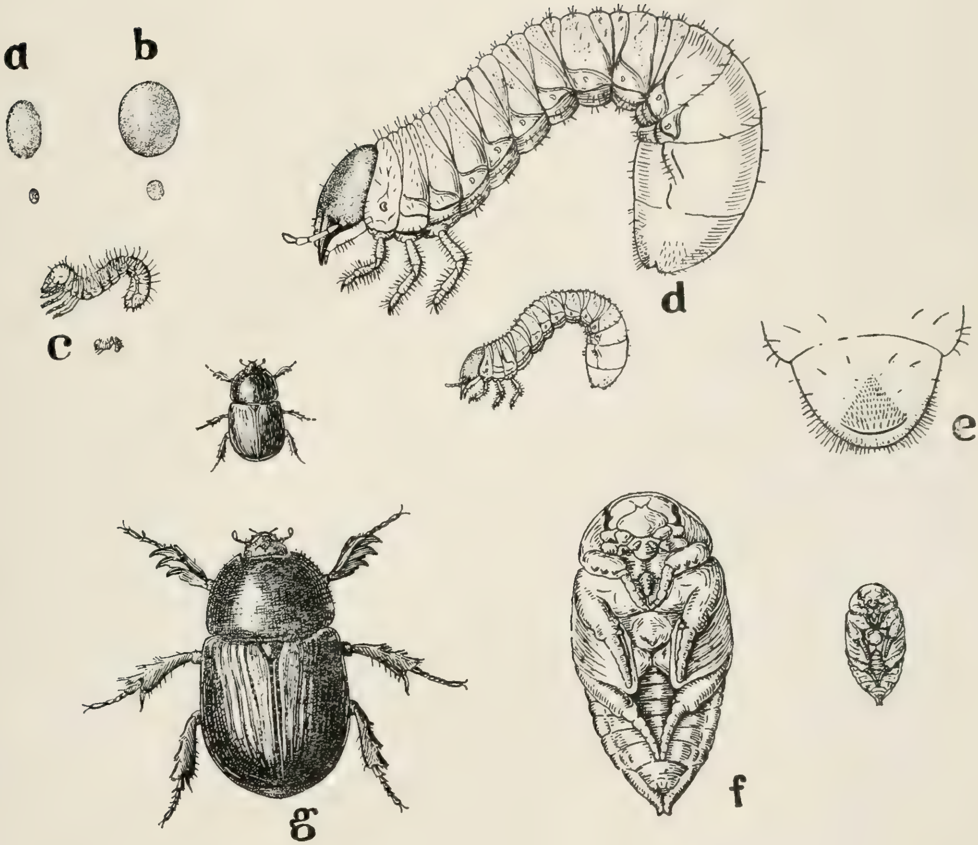
b, Larva (× 9).

c, Pupa (× 9).

d, *e*, Beetle (× 9).

(The smaller figures show the natural sizes.)

PLATE V.



Alissonotum impressicolle (C. S. 1949).

a, Egg freshly laid (× 4).
b, Developed egg before hatching (× 4).
c, Newly hatched larva (× 4).
d, Full-grown larva (×$2\frac{1}{2}$).
e, Spines on the ventral surface of posterior extremity of larva (× 4).
f, Pupa (× $2\frac{1}{2}$).
g, Beetle (× $2\frac{1}{2}$).

(The smaller figures show the natural sizes.)

Dynastine Beetles damaging Sugarcane at Kamrup.

A stool of sugarcane shoots with the sett, showing how the beetles bore into the sett and gnaw across shoots, grown as well as newly emerging.

b, A beetle (*Alissonotum impressicolle*).

living specimens brought from Kamrup. Success was only obtained with the first-named species. The adult beetles rested in the soil, without taking any food so far as could be observed, until October-November, when eggs were laid. The resultant grubs were reared on roots of maize growing in earth mixed with farmyard manure. The grubs did hardly any damage to the maize plants and seemed to feed mostly on the manure. They fed from November to March and developed into beetles in April. This species has therefore only one generation in the year but, unlike most cockchafers, the grubs are active during the winter. *Alissonotum piceum* most probably has a similar life-history. Only a few beetles were available to start the work and these rested in the adult stage, like those of *A. impressicolle*, one living until October; but no eggs were obtained. Of *Heteronychus sublævis* only one beetle was available for the work, which failed. The adult beetles of these three species were observed to appear at Kamrup in April 1919, and in last year's report it was stated, on the strength of our experience with Scarabæid beetles generally, that their emergence was delayed owing to the drought which prevailed at Kamrup in February and March. But now it appears, presuming that the beetles reared at Pusa emerged at their natural time, that April may be the normal time for their appearance. According to the observations of Mr. S. R. Gupta, Entomological Assistant, Assam, who has observed it at Kamrup, the adult beetles emerge from the latter part of March until the end of April, and grubs are found from June to January, and pupæ in February; it does not appear, however, that these grubs were actually bred out. As indicated in last year's Report, the beetles occur at Kamrup every year, breeding in large numbers, their grubs finding plenty of food in the rich humus over the extensive areas under wild grasses all around the Sugarcane Farm, but in normal years it is not considered that they are likely to do any extensive damage to sugarcane. This is corroborated by the experience of 1920, when the beetles occurred but did not cause serious damage. With unfavourable climatic conditions, as in

1919, however, they may cause damage unless they can be forestalled by a change in the planting time and also changes in the methods of cultivation so as to avoid the ill effects of drought on the setts lying in the ground. In this connection it may be observed that the whole of the loss sustained at Kamrup in 1919 was not attributable to these beetles; a very careful examination of all the plots, made at the time, showed that the beetles were not responsible for a loss of more than about 20 per cent. of the crop. The failure of setts to sprout owing to unfavourable climatic conditions could not be ascribed to the beetles. Further details of life-histories of these beetles, and especially the question of their normal control by natural enemies, can only be settled by further investigations on the spot.

In March 1920 a few specimens of *Autoserica* sp. were observed gnawing sugarcane shoots at Pusa in the same manner as the Dynastine beetles at Kamrup. It appears that this form of damage is possible by many Scarabæid beetles.

In September 1919 the Entomological Assistant, Assam, collected some grubs of *Anomala dussumieri* (Plate VII, fig. 1) amongst sugarcane roots at Kamrup and sent them to Pusa. The grubs were reared up and were found to hibernate as larvæ, and pupated and emerged as adult beetles in April. Apparently therefore this beetle has only one generation in the year.

Tanymecus hispidus (Curculionidæ) was sent in from Kamrup as attacking young sugarcane shoots in April.

Argyria tumidicostalis, Hmpsn., the borer referred to in the Report for 1917-18 as C. S. 1610, which is one of the most injurious of all the borers in sugarcane, was found in May 1920 in cane at Sadiya, in Upper Assam, all of a number of cane-borers collected there proving to belong to this species, which is now known to occur at Pabna, Jorhat, Dacca and Sadiya. It is to be hoped that it will not be introduced into other parts of India and too great precautions cannot be taken to prevent its transport in canes exported from Assam and Eastern Bengal into other parts of India.

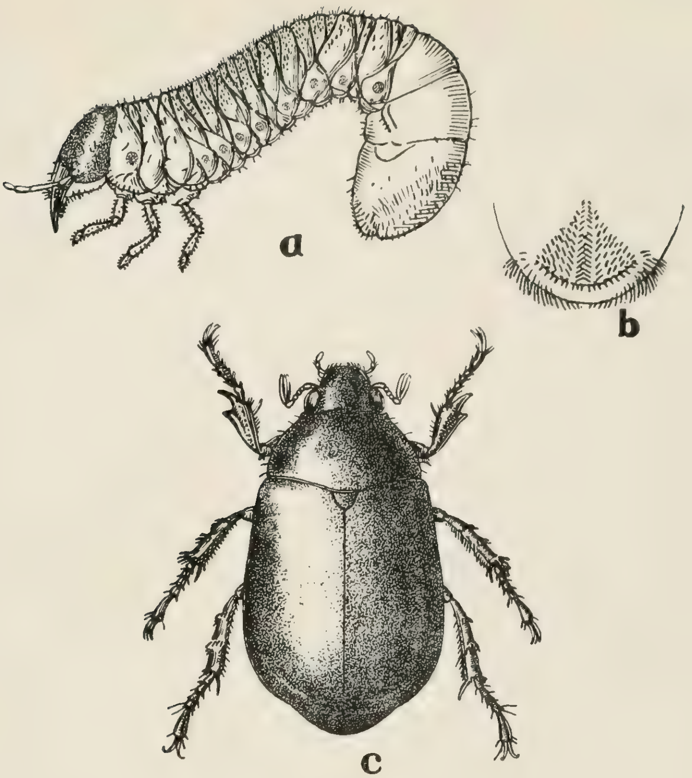


Fig. 1. *Anomala dussumieri* (C. S. 2000).

a, Larva (× 2).
b, Spines on the ventral surface of posterior extremity of the larva (× 2).
c, Beetle (× 2).

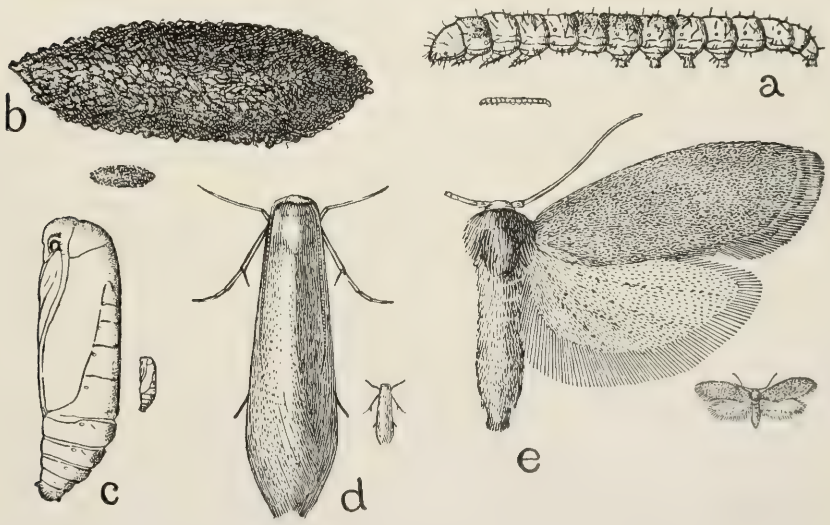


Fig. 2. *Achroia grisella* (C. S. 1853).

a, Larva, natural size and magnified (× 5).
b, Cocoon ,, ,, ,, ,, ,,
c, Pupa ,, ,, ,, ,, ,,
d, Moth, ,, ,, ,, ,, ,,
e, Moth, with wings spread, natural size and magnified (× 5).

New borers discovered during the year in gramineous and cyperaceous plants included :—

(1) *Hypsotropa tenuinervella*, Rag. (Pyralidæ; C. S. 1920), in stem of *Andropogon squarrosus* at Pusa. This has also been reared from the bulb of *Rosha* grass (*Cymbopogon schœnanthus*) by the Forest Zoologist.

(2) *Crambus corticellus*, Hmpsn. (Pyralidæ; C. S. 2007), in stem of *Scirpus corymbosus* at Nagpur, where it was found by Mr. J. L. Khare.

(3) *Chilo torrentellus*, Meyr. (Pyralidæ; C. S. 2027), in stem of *Saccharum spontaneum* at Pusa. This was reared successfully this year after unsuccessful attempts during the last three years.

(4) *Lychrosis zebrinus* (Cerambycidæ; C. S. 2010), in stem of *Saccharum spontaneum* at Pusa.

The search for alternative foodplants of borers in sugarcane, etc., was continued and the following of importance may be mentioned :—

(1) *Coix lachryma-jobi* var. *aquatica* as a foodplant of *Chilo simplex* on the Farm at Cuttack.

(2) Lemon-grass as a foodplant of *Sesamia inferens* at Pusa.

Brachytrypes portentosus (*achatinus*) (Gryllidæ) did some damage to cane at Pusa in June, cutting the shoots practically level with the ground; but these shoots grew again and practically none of them died.

Mulberry. Frequent reports have been received from Bengal regarding the damage done by *Phenacoccus hirsutus*, the mealy-bug scale-insect which is the cause of "*Tukra*." Collection of alternative foodplants showed that this scale was very common at Pusa on cotton and guava. From colonies on cotton many adults of the Cecidomyiad fly, *Diadiplosis indica*, Felt, which is predaceous on the egg-masses and adult females, were bred out and liberated to mark the effect of the predator. The Drosophilid fly, *Gitonides perspicax*, Knab, was also found last

year to be one of the predators that keeps this mealy-bug in check to some extent. Hitherto "*Tukra*" has been mostly reported from Bengal but it is possible that it has become widely distributed with mulberry cuttings sent out from infested localities. A Memoir on "*Tukra*" is in course of preparation by Mr. C. S. Misra.

Fruit Pests. Considerable material has been accumulated regarding insect pests of fruit trees, both collected locally and sent in by correspondents all over India seeking for identifications and advice.

Frequent reports were received from correspondents in Tirhut concerning *Batocera rubus*, a Lamiad beetle, which bores in mango trees in its larval stage.

The Cecidomyiad fly which makes galls on mango leaves and which was figured in last year's Report (tab. IX, fig. 2) has been identified by Professor E. P. Felt as *Procontarinia matteiana*, Kieffer and Cecconi.

Chætodacus zonatus (Trypaneidæ) was destructive to Peach fruits at Pusa in May-June. The trees were sprayed, early in the morning each day, with a solution of *gur* and lead arsenate, to destroy the adult female flies and the attacked fruits were collected and destroyed.

The weevil referred to in last year's Annual Report (page 92) as *Deiradognathus* n. sp., should have been called *Deiradolcus* n. sp., and the necessary corrections should be made.

The undetermined Sphingid found on apple at Shillong and referred to on page 95 of last year's Report has since been determined as *Langia zenzeroides* from specimens reared at Shillong by Major F. B. Scott.

The larva referred to on page 95 of last year's Report, as attacking apple fruits at Ramgarh, has since been reared in some numbers from material kindly supplied by Mr. Johnson, of Ramgarh, and proves to be a Tortricid, which Mr. E. Meyrick has named as *Cacœcia pomivora*, n. sp. Figures of the stages of this insect will be found in Entomological Memoir, Vol. VI, Part 9, tab. LVIII, fig. 1.

Another Tortricid larva has been found to bore into apple fruits at Shillong but can hardly be described as a pest, as it is not common as an apple-borer and seems merely to excavate a small chamber in the core without injuring the pulp of the fruit. This is the larva of *Ulodemis trigrapha*, Meyr., which has also been reared at Shillong from a larva feeding on flowers of *Colquhounia coccinea*. The stages of this species also will be found figured in Entomological Memoir, Vol. VI, Part 9, tab. LVIII, fig. 2.

A new and serious apple-pest was found at Shillong in October 1919 in *Ptochoryctis rosaria*, Meyr., a Xyloryctid moth whose red larva eats the bark of young apple twigs under cover of a silken tubular gallery. This insect has hitherto been known only from Bhutan. From a larva brought to Pusa the moth emerged in March. At Shillong the moths probably appear later in the year, as there seems to be only one brood on apple annually. The stages of this pest also are figured in Entomological Memoir, Vol. VI, Part 9, tab. LXIII, fig. 1.

An interesting and unexpected find on apple at Shillong in May and June, 1920, was *Helopeltis theivora*, the so-called "Tea Mosquito" bug, which in this case was found sucking young shoots of apple.

Specimens of *Brahmina coriacea*, Hope, *Holotrichia* sp., and of a third undetermined Melolonthine beetle were received from the Superintendent of the Kumaon Government Gardens, Ranikhet, as damaging fruit trees. Another Melolonthine, a species of *Microtrichia*, was received from Solan as damaging fruit-trees.

Life-histories of Insects. Besides the various insects named above, more than 150 different lots of insects have been reared during the year and observations made on life-histories and habits. In a Report of this nature it is only possible to mention a few of these even by name.

(1) *Achroia grisella*, Fo. (Galleriadæ) (Plate VII, fig. 2). During the last two years this wax-moth has occurred regularly at Pusa in hives occupied by the Indian Bee

(*Apis indica*) and proved destructive to a number of old stored combs. The caterpillar feeds on wax as well as on the debris that collects in a hive and even nibbles the felt blankets which are kept over the top of the frames. It also feeds on dry propolis, and seems to be a scavenger under natural conditions.

(2) *Chlumetia transversa* (Noctuidæ; C. S. 1960). The larvæ bore into mango shoots but can feed on the leaves also.

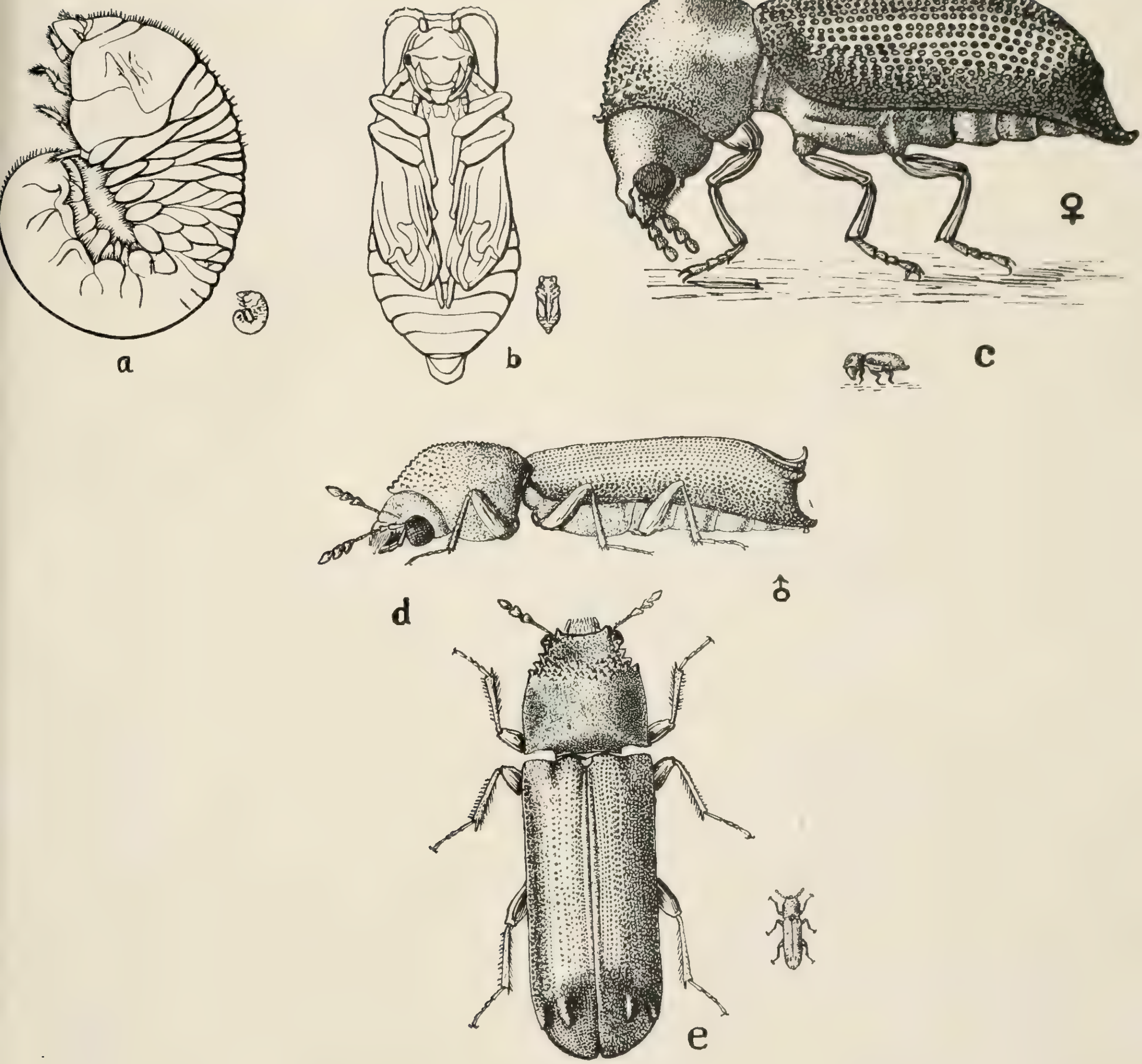
(3) *Camponotus maculatus infuscus* (Formicidæ; C. S. 1983). These black ants were observed to nibble the tender shoots, leaf-stalks and leaves of *brinjal* at Pusa in November. The shoots and leaves so attacked withered. In this way these ants may be a minor pest under favourable conditions.

(4) *Heterobostrychus æqualis* (Bostrychidæ; C. S. 2023) (Plate VIII). This dry-wood borer was received in September from Deolali where bully rafters were being destroyed by it. The grubs fed and developed and emerged as beetles in May-June and the insect seems to have only one generation in the year.

(5) *Sinoxylon anale* (Bostrychidæ) (Plate IX, fig. 1). Specimens of this species also were received from the Assistant Controller of Textile Stores, Bombay, as damaging articles made of wood, *e.g.*, packing cases, handles of brushes, etc.

(6) *Stromatium barbatum* (Cerambycidæ). Eggs of this Longicorn beetle were obtained at Pusa in June 1917 and the larvæ have been feeding now for three years in dry wood, no adults having emerged so far. This larva is a common wood-borer in household furniture and may evidently have a prolonged existence in the larval stage under dry conditions.

(7) *Agrotis ypsilon*, *A. flammatra* and *Euxoa spinifera* occurred in the gram fields at Pusa about March in practically equal numbers. Opportunity was taken to prepare a coloured plate showing the life-history of *Agrotis flammatra.*



Heterobostrychus æqualis (C. S. 1248).

a, Larva, natural size and magnified (× 6½).
b, Pupa, ,, ,, ,, ,, ,,
c, Beetle, female, natural size and magnified (× 9).
d, ,, male, side view (× 6).
e, ,, ,, dorsal view (× 6).

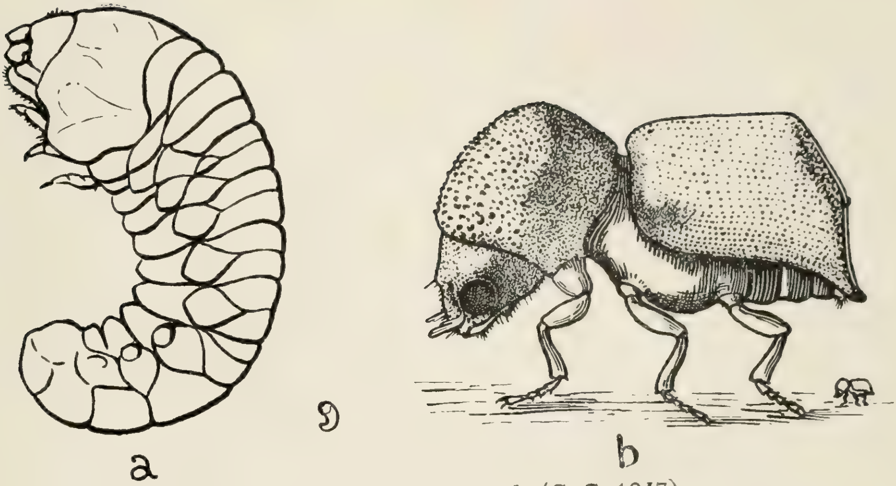


Fig. I. *Sinoxylon anale* (C. S. 1247).

a, Larva (× 14) ; *b*, Beetle (× 13).

(The smaller figures show the natural sizes.)

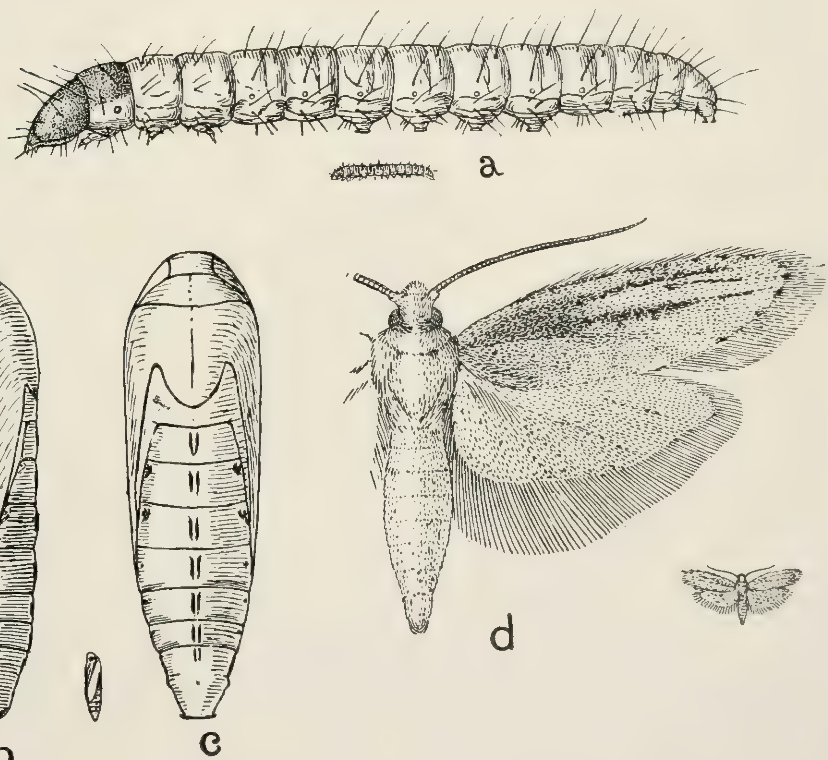
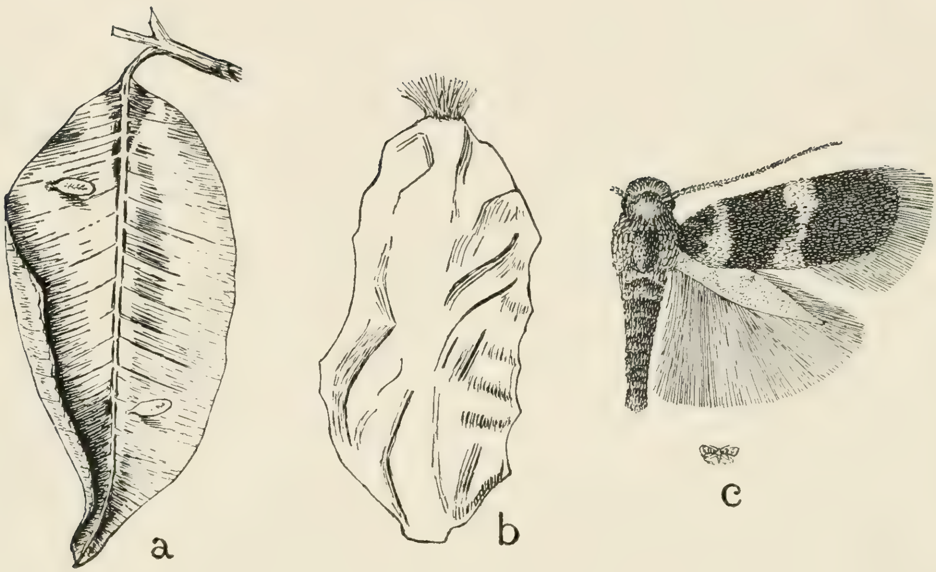


Fig. 2. *Corcyra cephalonica* (C. S. 1979).

a, Caterpillar (× 7) ; *b*, *c*, Pupa, lateral and dorsal views (× 7) ; *d*, Moth (× 7).

(The smaller figures show the natural sizes.)



Antispila anna (C. S. 1993).

a, Cocoons on leaf.

b, A single cocoon enlarged (× 16).

c, Moth, natural size and enlarged (× 16).

(8) *Juar* (*Andropogon Sorghum*) heads, affected by what is known as *khas* (*i.e.*, sterility) disease in Sind, were received through the Assistant Professor of Entomology at Poona. This disease is believed to be due to a minute Cecidomyiad fly. The affected spikelets do not form any grain and in this particular case many of the aborted growths in the spikelets exhibited a minute hole in their glumes through which the adult insect had apparently emerged. Many of those which did not show such a hole contained a minute red grub, but nothing could be reared out from these. It seems, however, probable that *khas* is due to a Cecidomyiad.

These *juar* heads contained some fully-formed grains, all of which were affected by *Sitotroga cerealella*, a small Gelechiad moth commonly found in granaries. It was, however, impossible to determine whether infection had taken place in the fields.

On the same heads a few caterpillars of *Corcyra cephalonica* (Galleriadæ; C. S. 1979) (Plate IX, fig. 2), another but less injurious granary pest, were found binding the grains together with silk and nibbling them. In this case also it was impossible to determine whether infection had taken place in the fields.

A new species of *Antispila* (Heliozelidæ) was sent in by Mrs. Drake, of Serampore, Bengal, as feeding on *Eugenia jambolana.* Specimens were reared at Pusa from the material received and have been named by Mr. E. Meyrick as *Antispila anna*, n. sp. (Plate X).

Stored Grain Pests. The results of our long series of experiments and the details of the successful method of storage under sand evolved therefrom for the storage of grains have been fully described in a paper, by the present writer and Mr. C. C. Ghosh, in the Proceedings of the Third Entomological Meeting, now in the press. Further work was continued during the year, especially with a view to finding out whether there is any infestation in the fields and, if so, to what extent. For this purpose samples of ripe ears of wheat and barley were collected from various fields on the Farm and are now under observation.

The Board of Agriculture, at their Meeting in December 1919, recommended that the problems of grain storage, with especial reference to the question of damage by insect pests, should be taken up on a large scale and that the staff of the Imperial Entomologist should be increased for this purpose. Proposals for an increased staff have been included in my general proposals for expansion of entomological work in India.

Trogoderma khapra (Dermestidæ) was under observation to ascertain its behaviour and seasonal history at Pusa. A long cycle occupied the whole period from end of June 1919 to March-April 1920. The moist weather during the Rains and the cold weather in the winter retarded the development of the larvæ.

IV. Bees, Lac and Silk.

Bees. No special work was done with bees except carrying on a few colonies of *Apis indica.* A number of improved hives were supplied to inquirers in various Provinces.

As noted above, *Achroia grisella* has now to be added to the list of enemies against which the bee-keeper has to contend.

Proposals have been forwarded for the entry of a bee-keeping expert in order to develop this important branch of Applied Entomology.

Proposals for legislation to restrict the importation of bees into India, with a view to avoid the importation of bee-diseases, are now before the Government of India.

Lac. The emergence of lac larvæ took place at Pusa on 29th October, 1919, and 30th June, 1920, the latter being a very unusually late date. Broodlac was sent to the Government Entomologist, Coimbatore, to the Superintendent of the Agricultural Farm, Ratnagiri, to Gwalior, Lyallpur and Mymensingh. There is a great demand for broodlac, which cannot be met from Pusa.

Mr. C. S. Misra, First Assistant, visited Bhopal State in December 1919 to advise regarding steps to be taken to develop the lac industry there.

The second edition of the Bulletin on Lac Culture in the Plains of India has been exhausted and a third edition is in preparation.

During the year several inquiries were received from Bengal regarding any possible connection between the presence of lac insects and pebrine in silkworms. Specimens of lac insects, received from Malda and Berhampore, did not reveal the presence of any pebrine bodies in the female insects and it is not considered likely that lac insects will be found to be affected by pebrine, but experiments on this line are being started. In this connection it may be noted that both lac and silkworms have been cultivated successfully at Pusa for more than ten years, which seems to dispose of the superstition current in the silkworm rearing districts of Bengal that cocoon crops cannot be successful if lac and silkworms be grown in the same place. The price of lac has advanced so much recently, having gone up to practically ten times the pre-war rates, that the question of lac-production in India has become one of no small economic importance.

Silk. The sericultural establishment is still on a temporary footing which has been extended up to 31st March, 1921. In the meantime experiments on mongrelization of mulberry silkworms have been continued to see whether the mongrel races will continue to give silk superior in quality and quantity to that of the indigenous multivoltine races. It will take some time to arrive at definite conclusions regarding the results of these experiments.

Univoltine races of Bengal, China, Japan and France, and their hybrids, were sent for cold storage to Guindy, Muktesar and Shillong, and were successfully reared at Pusa in October-November and in February-March. Tasar worms were reared in captivity, as well as on trees, and their diseases were studied.

Mulberry silkworm eggs have been supplied to 69 applicants and mulberry seeds and cuttings to 26 applicants, including the Director of Industries, Assam, the Superintendent of the Northern Shan States, the Director of

Agriculture, Bengal, and the Silk Departments of Travancore, Gwalior, Indore and Banganapalle States. Eri silkworm eggs have been supplied to 91, and castor seeds to 5 applicants, including correspondents in Japan, Egypt and England. Three Pusa Twisting Machines were supplied to the Director of Industries, Assam, the Director of Sericulture, Patiala, and the Tyler Weaving School, Shahjahanpur. Two rearers and one reeler were sent to the Superintendent of the Northern Shan States, and one reeler and one rearer to the Assistant Registrar of Co-operative Societies, Lower Burma, to assist the sericultural industry in Burma. Show-cases showing stages in the preparation of eri and mulberry silk were sent to the Deputy Collector on special silk duty, Benares, and to the Curator of the Victoria Museum, Karachi. Numerous inquiries regarding sericulture were dealt with and assistance given to inquirers as far as possible. Silk pieces to the value of Rs. 1,636-6-0 were sold and the proceeds credited to Government and a further Rs. 468-13-0 worth of pieces were made and kept as samples.

Silk exhibits to demonstrate rearing, reeling, twisting, spinning and reversing were sent to Calcutta and Bankipur in connection with the Peace Day Celebration Exhibitions, and a silver medal was awarded by the latter Exhibition. Silk exhibits were also sent to Exhibitions at Unao, Chittagong and Muzaffarpur.

A Bengali version of Bulletin No. 74, on the experiments carried out at Pusa to improve the Silk Industry, was published.

Three students completed the course in sericulture and two others remained under training at the end of the year. Two students from the Sabour Agricultural College were also given some instruction in sericulture.

V.—Illustrations.

Coloured plates illustrating the life-histories of the following insects were prepared during the year, *viz.*, *Agrotis flammatra* and *Cosmophila sabulifera*. A large

number of colour-notes of Indian Odonata was also done. Besides these, about two hundred illustrations in black and white, illustrating the life-histories of various insects reared in the Insectary, were also prepared.

A large number of coloured plates and black and white illustrations are now in the press in connection with the Proceedings of the Third Entomological Meeting and various Memoirs and Bulletins.

VI. Miscellaneous.

Correspondence. A total of 60 parcels of specimens, mostly of crop-pests, was received during the year for identification and advice, whilst 800 letters were received and 1,088 issued; these numbers show a slight decrease on previous years but are exclusive of a large amount of routine correspondence which takes up a considerable proportion of time which should be devoted to more scientific work.

VII. Insect Survey.

Steady progress has been made in addition to, and arrangement and identification of, the collection which is now a large and important one and continues to expand at a rapid rate. In view of the great value of this collection, both from an economic and systematic point of view, to future students of Indian Entomology, every effort is made for the proper preservation of the large mass of specimens, a task which is by no means easy in a climate such as that of Pusa. This year, for example, owing to the abnormal heat in June, the paraffin-wax in the store-boxes melted. The more irreplaceable portions of the collection and those liable to most damage from mould are therefore being placed in cabinets which are being obtained as rapidly as possible. The staff required for the upkeep (which includes the sorting and identification, as well as the mere preservation, of the *lakhs* of specimens already accumulated and of the thousands received every year) has not been increased since a time, many years ago, when the collection was comparatively quite small; yet this work is

constantly expanding and has already become very heavy, although this is only one branch of the activities of the Entomological Section.

During the year small lots of Ichneumonidæ, Tenthredinidæ and Bees have been returned named after examination by Messrs. Morley, Rohwer and Professor Cockerell respectively. The collection of Hymenoptera is in good order and well named up except for the Braconidæ and Chalcidoidea.

The collection of Coleoptera is in fair order but there is a large amount of unnamed material to be sorted out, named and incorporated. The Bruchidæ sent to Dr. G. A. K. Marshall have been returned, partially named, and a few Curculionidæ have also been received back, named, from Dr. Marshall. Staphylinidæ were received back, named, from Dr. M. Cameron and Carabidæ from Mr. H. E. Andrewes. A small lot of Cicindelidæ sent to Mr. S. W. Kemp was received back unnamed. On receipt of the "Fauna" volume on Hispinæ and Cassidinæ the occasion was taken to revise and name up the whole of the Hispinæ and part of the Cassidinæ. The Paussidæ also have been revised and identified.

The Lepidoptera are in fair order but many accessions remain to be incorporated. The Microlepidoptera collection is contained in cabinets and is by far the largest collection in India; a few specimens were sent to Mr. Meyrick for identification and have been received back named.

The Orthoptera have not been arranged since the late W. F. Kirby identified the earlier collections ten years ago. Since then a mass of material has accumulated and arrangements have now been made for it to be worked over by Mr. Morgan Hebard, of Philadelphia, to whom the collection will be sent for study as soon as the necessary boxes have been received.

The Neuroptera (*sensu antiquo*) also require a good deal of work. The Odonata have been revised during the last year and this portion of the collection has been greatly

extended and is now fairly representative of the Indian Region. Arrangements have been made with Mr. Esben Petersen, of Denmark, to work over the Myrmeleonidæ and allied groups, and these will be sent to him for study.

The small collection of Diptera has been studied and mostly named up by Mr. E. Brunetti so far as concerns the Nematocera and Brachycera, but requires considerable rearrangement which will, it is hoped, be taken up this cold weather.

The Rhynchota require a whole-time worker to go over the vast accumulation of specimens and reduce them to order. Several consignments of Coccids were sent out for identification during the year.

The following collections, sent out in previous years, have not yet been returned :—

(*i*) Histeridæ to Mr. G. Lewis.
(*ii*) Longicorn beetles to Dr. Gahan.
(*iii*) Rhynchota to Mr. W. L. Distant.
(*iv*) Tetriginæ to Dr. J. L. Hancock.
(*v*) Aquatic Rhynchota to the late Mr. C. A. Paiva.
(*vi*) Hispinæ and Cassidinæ to Professor S. Maulik.

Numerous collections of Indian insects have been received and named and returned as far as possible. These included collections sent by the Forest Research Institute, the Provincial Agricultural Departments, the Bombay Natural History Society, and by numerous correspondents.

VIII. Catalogue of Indian Insects.

At the Third Entomological Meeting, held at Pusa in February 1919, it was resolved that there is considerable need of a catalogue of all described Indian Insects with complete references to literature concerning them, especially that published in India, and a Standing Committee was formed to give effect to this resolution. During the past year this work has been pushed on as far as possible and I have brought up to date catalogues of all families of

Microlepidoptera and Neuroptera, have prepared new catalogues of Phasmidæ, Mantidæ, Gryllidæ and Phasgonuridæ, and have supplied references to publications during the year on Indian Insects as regards Coleoptera, Rhynchota and Diptera to Messrs. Beeson, Andrews and Senior-White who are respectively responsible for these sections of the general catalogue. The Acrididæ remain to be taken up to complete the Orthoptera and it is hoped to do this in the near future.

IX. Programme of work for 1920-1921.

Major.

This will follow generally on the lines of work of the current year and will include general investigations of crop-pests and especially of the pests of sugarcane, rice and cotton, of fruit-trees, and stored grain.

Minor.

Results in various lines of work require to be written up and published as far as possible. Work and experiments in silk, lac, and bee-keeping will be continued and new insecticides and insecticidal methods tested as occasion arises. Systematic work on Indian insects will be carried out with our resources and the help of specialist correspondents. The catalogue of Indian insects will be proceeded with. Advice and assistance will be given as far as possible to Provincial Departments and to all inquirers on entomological subjects.

X. Publications.

The following publications, either written by the Pusa staff or based on material sent from Pusa, have been actually issued during the year ended 30th June, 1920 :—

Brunetti, E. . . Diptera Brachycera, Vol. I. (*Fauna of India* series.)

Cameron, M. . . New species of Staphylinidæ from India. I. (*Entom. Mo. Mag.*, June 1920.)

Cockerell, T. D. A. .	Descriptions and records of Bees. LXXXVII. (*Ann. Mag. Nat. Hist.* (9), IV, 355-360.)
,,	Some Indian Bees of the genus *Andrena*. (*Entom.*, June 1920.)
De, M. N. . . .	Bengali edition of Bulletin 74 on the experiments carried out at Pusa to improve the Silk Industry.
Dutt, G. R. . .	Entomological Notes 105, 106. (*Pusa Bull.* 89.)
Elliot, E. A. . .	Two new Stephanidæ. (*Entom.*, III, 162-163.)
Felt, E. P. . .	New Indian Gall Midges. (*Entl. Mem.*, Vol. VII, No. 1.)
Fletcher, T. Bainbrigge.	Entomological Notes 102-104, 107-113, 115-118, 121-128, 130-145, 147-150, 152, 153, 157, 158, 160-165, 167, 168, 170, 172, 173, 178-180, 182-185, 187, 189, 190, 193, 197, 199, 200. (*Pusa Bull.* 89.)
,,	Agricultural Entomology. (*Ann. Rep. Bd. Sci. Adv. India*, 1918-19.)
Fraser, F. C. . .	Notes on some new and other Indian Dragonflies. (*Journ. Bomb. Nat. Hist. Soc.*)
,,	Description of a Rhinocyphine larva from Shillong. (*Entl. Mem.*, Vol. VII, No. 2.)
Marshall, G. A. K. .	Some new injurious Weevils from Asia. (*Bull. Ent. Res.*, IX; July 1919.)
Maulik, S. . .	Chrysomelidæ, Hispinæ and Cassidinæ. (*Fauna of British India.*)
Meyrick, E. . .	Exotic Microlepidoptera, Vol. II, pts. 8-10.
Ramachandra Rao, Y.	*Lantana* Insects in India, being the report on an inquiry into the efficiency of indigenous insect pests as a check on the spread of *Lantana* in India. (*Entl. Mem.*, Vol. V, No. 6.)
Rohwer, S. A. . .	Three new species of Indian Drynnid parasites of Rice Leaf-hoppers. (*Proc. U. S. Natl. Mus.*, LVII; June 1920.)

In addition to the foregoing, the following publications were in the press at the close of the year :—

De, M. N. . .	The Pusa experiments on the improvement of Mulberry Silkworms. (*Rep. of Proc. of Third Entl. Meeting*, pp. 800-808.)
,,	The best method of eliminating Pebrine from multivoltine Silkworm races in India. (*loc. cit.*, pp. 809-835.)
Fletcher, T. Bainbrigge.	Annotated List of Indian Crop-pests. (*Rep. of Proc. Third Entl. Meeting*, pp. 33-314.)
,,	Life-histories of Indian Microlepidoptera. (*loc. cit.*, pp. 838-857.)
,,	Hints on collecting and preserving Insects. (*loc. cit.*, pp. 936-974.)
,,	Note on a very curious Geometrid larva. (*loc. cit.*, p. 978.)
,,	Indian Epipyropidæ. (*loc. cit.*, pp. 978-982.)
,,	Indian Fossil Insects. (*loc. cit.*, pp. 982-989.)
,,	The desirability and practicability of the preparation and publication of a General Catalogue of all described Indian Insects. (*loc. cit.*, pp. 989-999.)
,,	Note on Plant Imports into India. (*loc. cit.*, pp. 1051-1069.)
,,	Life-histories of Indian Insects: Microlepidoptera. Pterophoridæ. (*Entl. Mem.*, Vol. VI, No. 1.)
,,	Ditto: Carposinidæ, Phaloniadæ, Tortricidæ and Eucosmidæ. (*loc. cit.*, No. 2.)
,,	Ditto: Gelechiadæ. (*loc. cit.*, No. 3.)
,,	Ditto: Cosmopterygidæ, Œcophoridæ, Physoptilidæ, Xyloryctidæ, Stenomidæ and Orneodidæ. (*loc. cit.*, No. 4.)
,,	Ditto: Heliozelidæ, Heliodinidæ, Glyphipterygidæ, Blastobasidæ and Hyponomeutidæ. (*loc. cit.*, No. 5.)
,,	Ditto: Gracillariadæ. (*loc. cit.*, No. 6.)

Fletcher, T. Bainbrigge.	Life-histories of Indian Insects: Epermeniadæ, Plutellidæ and Lyonetiadæ. (*loc. cit.*, No. 7.)
,,	Ditto: Tineidæ and Nepticulidæ. (*loc. cit.*, No. 8.)
,,	Ditto: Appendix. (*loc. cit.*, No. 9.)
Fletcher, T. Bainbrigge and Ghosh, C. C.	Borers in Sugarcane, Rice, etc. (*Rep. of Proc. of Third Entl. Meeting*, pp. 354-418.)
,,	The preservation of wood against Termites. (*loc. cit.*, pp. 705-712.)
,,	Stored Grain Pests. (*loc. cit.*, pp. 712-761.)
,,	Notes on rearing Insects in hot countries. (*loc. cit.*, pp. 875-892.)
Fletcher, T. Bainbrigge and Misra, C. S.	Cotton Bollworms in India. (*loc. cit.*, pp. 443-472.)
Ghosh, C. C. . .	A Note on Crabs as pests of Rice. (*Rep. of Proc. Third Entl. Meeting*, pp. 680-689.)
,,	Bee-keeping in India. (*loc. cit.*, pp. 770-782.)
,,	Suggestions regarding publication of communications on Indian Insects. (*loc. cit.*, pp. 1034-1042.)
,,	Some aspects of Economic Entomology in India. (*loc. cit.*, pp. 1072-1080.)
Misra, C. S. . .	Some Indian Economic Aleyrodidæ. (*Rep. of Proc. Third Entl. Meeting*, pp. 418-433.)
,,	The Rice Leaf-hoppers. (*loc. cit.*, pp. 433-443.)
,,	Some pests of Cotton in North Bihar. (*loc. cit.*, pp. 547-562.)
,,	Index to Indian Fruit-pests. (*loc. cit.*, pp. 564-596.)
,,	*Tukra* disease of Mulberry. (*loc. cit.*, pp. 610-618.)
,,	Lac-culture in India. (*loc. cit.*, pp. 782-800.)

Misra, C. S. . .	The Rice Leaf-hoppers. (*Nephotettix bipunctatus, Fabr. and Nephotettix apicalis*, Motsch.) (*Entl. Mem.*, Vol. V, No. 5.)
,,	Woolly Aphis. (*Agricl. Journ. India.*)
Ramachandra Rao, Y.	*Lantana* Insects in India. (*Rep. of Proc. Third Entl. Meeting*, pp. 671-680.)

REPORT OF THE IMPERIAL PATHOLOGICAL ENTOMOLOGIST.

(The late F. M. Howlett, B.A., F.E.S.)

(Mr. Howlett died at Masuri on 20th August 1920, before writing his Annual Report for the year ended 30th June 1920. The following Report has been written by me from such information as is available.—T. Bainbrigge Fletcher, Imperial Entomologist.)

I. Charge and Establishment.

The Imperial Pathological Entomologist was in charge of the Section during the year. The deputation period under the Indian Research Fund to conduct an investigation into mosquito repellents expired on 24th July 1919. The Imperial Pathological Entomologist left Pusa for Dehra Dun on 4th February 1920, to take charge of the Zoological Branch of the Forest Research Institute and College in addition to his own duties. He was in charge of the Forest Zoologist's office from February to 9th July 1920.

At the request of Mr. H. E. Cross, Camel Specialist, Sohawa, Mr. P. G. Patel has been deputed to work with him on Surra transmission experiments.

Mr. H. N. Sharma was on deputation in connection with the mosquito repellents investigation until 24th July 1919.

M. Shaffi, Fieldman, was on deputation for six months from July 1919 in connection with the Kala-Azar investigation at the Pasteur Institute, Shillong.

II. Work Done.

In September 1919 the Imperial Pathological Entomologist took up work on the effect of alkaloidal poisons on rats (undertaken at the suggestion of the Secretary, Indian Research Fund Association), and of X-rays on mosquito-larvæ, in collaboration with Captain Barnard of Colaba

Hospital. He also attempted to discover the insect carrier of a short-period fever which was seriously impairing the efficiency of ships' crews in dock. Experiments were also undertaken at Bombay on ridding railway carriages of bed-bugs, at the request of the Bombay Baroda and Central India Railway.

As arranged by the Hon'ble Member and the Military authorities, the Imperial Pathological Entomologist was directed to resume Surra work and carry out a fly-survey in the Punjab and North-West Frontier Province. He accordingly left Bombay on 25th September 1919 for this work and visited the following places with Messrs. P. G. Patel and S. K. Sen, Assistants, in connection with this survey, *viz.*, Karachi, Jacobabad, Quetta, Lahore, Campbellpur, Basal, Jhalar, Nowshera, Attock, Lawrencepur and Peshawar, and many other small villages. In connection with this work also, an abstract of all reports received from Veterinary Officers with regard to Surra and Horse Flies has been sent to the Director, Veterinary Services in India, Simla.

The Mosquito Campaign on the Pusa Estate was continued throughout the year.

Mr. P. G. Patel, Entomological Assistant, reports as follows on his work during the year :—

" From November 1919 to February 1920 observations were made regarding the activity of the parasites of Tabanidæ.

" Tabanid parasites are in the habit of laying their eggs inside the eggs of *Tabanus.* The egg-laying period of Tabanidæ is (1st brood) from February to April, (2nd brood) from June to July, and (3rd brood) from September to October. There are certain species of *Tabanus* which may be found to lay their eggs either in May or August, but the majority behave in the manner stated above.

" Tabanid parasites have been observed during the whole egg-laying period of Tabanidæ more or less, but no record seems to have been made regarding the behaviour of Taba-

nid parasites during the cold season when the adult Tabanid flies are said to be absent.

"I started collecting egg-masses and examining them for parasites from the beginning of November 1919. On the 3rd November 1919, 33 egg-masses of *Tabanus sanguineus*, 11 egg-masses of *T. albimedius* and 7 of *Chrysops stimulans* were obtained. Nearly half of these eggs were found empty. The egg-masses of larger species, namely *T. albimedius* and *T. sanguineus*, were found infested with parasites, the *Chrysops* eggs being free from the parasite. On 10th November 1919, parasitized egg-masses of *T. albimedius* and *T. crassus* were collected; parasites from the eggs of both these species were seen emerging on 11th and 12th November. Two *T. albimedius* were seen on the river bank on this date. On 15th November 1919, nine egg-masses of *T. sanguineus*, two egg-masses of *T. albimedius*, eleven of *T. bicallosus* and one of *C. stimulans* were collected. Parasites from egg-masses of *T. sanguineus* and *T. albimedius* only were noted to emerge from 17th to 20th November 1919. One adult fly of *Tabanus crassus* was seen at this time. Full-grown larvæ of *T. albimedius* were met with on 21st November 1919. On 24th November 1919, 57 egg-masses of *T. crassus*, 9 unhatched and 48 hatched, were obtained. No adult fly was noted on this date.

"On 27th November 1919, five egg-masses of *Chrysops stimulans* and 2 hatched ones of the same species were obtained. No parasites were found to emerge from these eggs.

"Five egg-masses of *T. albimedius* and 4 old egg-masses of the same species were collected on 28th November 1919. Parasites from these eggs were noted on 30th November 1919. No trace was seen of *T. hilaris*, *T. nemocallosus* or *T. brunnipennis*, which are common during the Rains at Pusa. Full-grown and also young larvæ of *T. albimedius* were obtained on 30th November.

"Three egg-masses of *T. bicallosus* were collected on 30th November. From one of these there emerged four

very small parasites on 2nd December. These parasites were different from those of the larger species of *Tabanus*.

"Parasitized egg-masses of *T. albimedius* and *T. crassus* were obtained on 2nd December.

"Fifty-one egg-masses of *T. crassus* and *T. albimedius* were obtained on 8th December but only six of them were found to contain larvæ and parasites. Parasites began to emerge on 11th December.

"Eggs of *T. sanguineus* and *T. albimedius* collected on 27th November were examined on 8th December and a few were found to harbour parasites in their pupal stage.

"The following egg-masses, both old and fresh, were obtained on 10th December, *viz.*, 54 egg-masses of *T. crassus*, 29 of *T. bicallosus*, 7 of *C. stimulans*, 5 of *T. albimedius*. Of these only unhatched egg-masses of *T. albimedius* and *T. crassus* were found to contain parasites.

"One egg-mass of *T. albimedius* was taken on 11th December; parasites from this egg-mass began to emerge on 13th December; all these parasites were quite active and some of them were seen to be pairing.

"Several egg-masses of spiders, which were found near the egg-masses of *Tabanus*, were also collected to see if the *Tabanus* parasites could be obtained from them. Many spiders' eggs were found infested with hymenopterous parasites, but they were quite different from those of *Tabanus*.

Three egg-masses of *T. albimedius* were obtained on 15th December; and one of these began to hatch larvæ on 17th December; parasites began to emerge on 19th and 20th and were found pairing on 21st December, some of them surviving until 31st December. The total number of parasites which emerged from a single egg-mass of *T. albimedius* was 237, whereas the number of larvæ which emerged from the same egg-mass was 55.

"Thirteen egg-masses of *T. sanguineus* and two of *T. albimedius* were obtained on 18th December and from these parasites were seen to emerge on 23rd December.

" One egg-mass of *T. crassus*, obtained on 23rd November, began to hatch out parasites on 20th December; this egg-mass was kept undisturbed outside the Laboratory in a tank full of water and mud, and the parasites were noticed to survive until 6th January 1920.

" Fresh egg-masses of *T. bicallosus* and *Chrysops* sp. were found on 26th December, but no parasites emerged from these eggs.

" One old egg-mass of *C. stimulans* was examined carefully and was found to contain several parasites of a smaller variety.

" Two very old egg-masses of *T. albimedius*, covered up with a kind of fungus, were obtained on 4th January. One of these was opened up on that date and was found to contain living parasites.

" One egg-mass of *T. sanguineus* was noticed to hatch out parasites on 4th January.

" One egg-mass of *T. albimedius* began to hatch out larvæ on 7th January. The parasites from the same mass emerged on 8th January.

" The total number of parasites which emerged from a single egg-mass of *T. albimedius* was 253 and the number of larvæ which emerged from the same mass was 57.

" One old egg-mass of *C. stimulans* was found to contain parasites (small variety) on 9th January.

" One egg-mass of *T. sanguineus* obtained on 31st December began to hatch out larvæ on 7th January 1920; parasites emerged from this mass on 9th January.

" Several parasites were seen emerging from the egg-masses of *T. albimedius* and *T. crassus* which were collected during the second week of December; on breaking open the egg-masses, the parasites were found alive on 15th January.

" One egg-mass of *T. crassus*, collected on 11th January, was seen hatching out parasites on 18th January.

" One egg-mass of *T. albimedius* type, which was covered up with fungus, began to hatch out parasites on 29th January.

"One freshly-laid egg-mass of *C. stimulans* was found on 8th February.

"Eleven egg-masses of *C. stimulans* were obtained on 15th February; no parasite emerged out of them.

"One adult *T. albimedius* was seen on 20th February.

"Three old egg-masses of *T. crassus* were obtained on 23rd February, but no trace of parasites was seen amongst them.

"Three freshly-laid egg-masses of *T. albimedius* were obtained on 23rd February, and by 27th February 71 parasites emerged from these egg-masses.

"One egg-mass of *T. bicallosus* was observed on 23rd February with one parasite on it; it was kept under observation and seven parasites were found to emerge on 1st March.

"Between 25th and 26th of February 91 egg-masses were collected; they belonged to *T. albimedius*, *T. virgo*, *T. bicallosus* and *C. stimulans*.

"Egg-laying of Tabanids was noted in large numbers at Birouli *ghat* where the Estate cows were accustomed to graze.

"Besides the foregoing, work on the parasites of birds was continued at Pusa, the following parasites being obtained from different nests :—(*i*) Two species of blood-sucking midges of the genus *Culicoides* were found in very large numbers in crows' nests. The nest of a crow was invariably found lined with horse hairs and the midges were found inside the hairs quite inflated with blood. The members of the genus *Culicoides* are in the habit of drawing more blood than they can carry on the wing; I have very often marked these flies quite incapable of flying after their meal of blood. About 6 per cent. of the crows' nests were found infested with blood-sucking midges whereas the nests of several other birds which were examined on various occasions did not reveal the presence of these midges. (*ii*) *Squirrel bug:* This bug has proved to suck blood of man, rabbit and goat under Laboratory conditions. It was found mainly inside the nests of squirrels. It belongs to

the family Lygæidæ. No bug of this family has hitherto been recorded to suck blood, although many of them are known to harbour Flagellates, either *Herpetomonas* or *Crithidia*. The life-history of this bug, from egg to egg, has been worked out. (*iii*) A species of *Stomoxys*, apparently *S. oblongata*, was found to breed inside the nest-materials of the *Mynah* and of a kite. (*iv*) *Phlebotomus argentipes:* Flies of this species were observed to emerge out from the nest-materials which were heaped up in a glass aquarium. On examining the nest-materials no larvæ were seen but seven empty pupal cases were met with. Flies of this species were also noticed on several occasions in very large numbers inside the cages of Ostriches and other birds in the Victoria Garden at Bombay. (*v*) *Clinocoris hemipterus* (*Cimex rotundatus*) was obtained from a *Mynah*'s nest, which was situated on a wall of the Tara Stable at Pusa. All the stages of the bug including moults were recovered from the nest. Five pupæ of *Hippobosca maculata* were also found in this nest. (*vi*) A Muscid Fly was found to breed in the nests of a bird called *Siroli* in Bihar. (*vii*) The life-history of *Passeromyia* sp., perhaps *heterochæta* (blood-sucking maggots), has been worked out from egg to egg with a plate. One other kind of blood-sucking maggot has lately been obtained from the nest of a crow at Sohawa."

Mr. S. K. Sen, Entomological Assistant, submits the following report on his work during the year :—

"(1) The experiments started with a view to finding out the correspondence, if any, between the toxicity of salts and their position in the Periodic system were concluded. All the chlorides of Group iii (1), *i.e.*, $CaCl_2$ $BaCl_2$ and $MgCl_2$ behaved similarly, their toxicity being small, but the behaviour of $BaCl_2$ was not quite clear, for in two instances it showed rather pronounced toxicity. $CdCl_2$ which, along with $HgCl_2$ and $ZnCl_2$, falls under Group ii (2), proved to be highly toxic; $ZnCl_2$ had the disadvantage of forming basic precipitate in which condition, however, it appeared highly toxic. With regard to Group i (1), *i.e.*, LiCl, NaCl,

KCl (and NH_4Cl), all, except LiCl, appeared to have very little toxicity, the exceptional behaviour of LiCl being what was expected. It should be mentioned that as some of the chlorides were insoluble in water, attention had to be confined only to those chlorides that entered into true solution with water, and for the study of toxicity equimolecular solutions of the salts were always taken.

"(2) Experiments were continued on the correspondence of the toxicity of volatile organic compounds to their boiling points. Cotton plugs thoroughly soaked in the chemicals were allowed to remain for 48 hours in small phials containing a thin layer of water, care being taken not to bring the plug in contact with the water. Three larvæ of *Stegomyia scutellaris* were then introduced in each of the phials and the time when they died noted. The data so far obtained are scanty and do not warrant a definite conclusion.

"(3) Observations were continued on the comparative behaviour of larvæ and pupæ of mosquitos towards soluble and insoluble salts and poisons. Whereas mosquito larvæ are generally readily killed by minute quantities of HgCl sprinkled in water, the pupæ have almost always been found to resist the action of the salt and to turn into adults. The same was observed with other halogen salts of mercury which were insoluble in water and also some of the insoluble alkaloids. The results obtained seemed to confirm the previous conclusion that the soluble substances operate chiefly cutaneously and the insoluble substances orally ('Effect of mercurous chloride on mosquito larvæ,' read before the Sixth Science Congress).

"(4) In connexion with the Imperial Pathological Entomologist's work on 'Culicifuges' a series of concurrent observations was carried out on the deterrent effects of the following chemicals on *Chœtodacus zonatus* with a view to finding out any analogy between the chemotactic reaction of fruit flies and that of mosquitos. The experiment consisted in dissolving varying quantities of methyl eugenol

in spirit, adding fixed quantities of the repellents to the solutions and exposing the mixture in equal quantities. The following is an abridged statement of the average number of flies that came to the repellents (which were tried in various strengths): Cinnamic aldehyde, 0; Turpentine, 38·2; Camphor, 17·4; Napthaline, 22·6; Kerosine, 12·2; Benzine, 26·8; Acetic acid, 19·2; Carbolic acid, 0; Oxalic acid, 11·8; Hydrochloric acid, 10·8; Sulphuric acid, 3·4; Mercuric chloride, 0; Soap (unscented), 12·8; Formalin, 28·6; Amyl acetate, 78; Control (Methyl eugenol only), 33·2. Some chemical change seemed to have taken place in the case of mercuric chloride.

"(5) A further attempt was made to find out the rôle of blood in ovulation in mosquitos. In my previous paper it was stated that eggs were obtained with peptone and in a few cases with milk, but the exceedingly small percentage of successful experiments pointed to some accidental factor being responsible for ovulation. The following were some of the standpoints from which the problem was attacked :—

(*i*) Leucocytes are present in the blood of both vertebrates and invertebrates (which have been found to be attacked by mosquitos). As leucocytes are characterized by amæboid movements and also in some other respects they present a near parallel to *Amœba* and *Euglena*, it was considered probable that the larval habit of eating *Euglena* in water was continued into the adult habit of eating leucocytes (while sucking blood); and if so, *Euglena* might take the place of leucocytes even during the adult stage. But out of the three experiments tried with *Euglena* (sweetened with cane sugar), only in one case were eggs laid by *S. sugens*. The three experiments were continued for three weeks. The result is, however, of interest inasmuch as this is the first instance in which eggs were obtained with a mosquito other than *S. scutellaris* without any meal of blood.

(*ii*) Eggs were obtained in two out of four experiments tried with shed goat's bloods (sweetened with cane sugar). With a view to studying the effects of the different constituents of blood, attempts were made to separate out the serum from the shed blood by means of a centrifuge but this did not succeed, probably on account of failure to prevent coagulation.

(*iii*) Willstätter has recently confirmed the analogy that was believed to exist between chlorophyll and hæmoglobin, but no eggs have hitherto been laid by mosquitos fed with sweetened plant juice.

(*iv*) Mosquitos enclosed with tender plants (from which they could suck the juice if they would) died within four days without ovipositing.

(*v*) In view of Goeldi's opinion that 'honey and other sweet substances have an inhibitory or neutral influence on reproduction,' saccharine and glycerine in various strengths were offered to the mosquitos but they refused even to taste any of the liquids.

"(6) A large number of experiments was carried out on the behaviour of bed-bugs in a varying temperature. Healthy adult bed-bugs were enclosed in very small air-tight tubes designed to contain the least possible amount of air, and the tubes containing the bugs were immersed in water kept at a fixed temperature by means of electric current. The experiments necessitated sustained observation in order to discriminate between apparent and real death. The main issue of the experiments was the establishment of the fact that a two minutes exposure to a temperature of 52°C. is generally sufficient to kill the bed-bug.

"(7) In July 1919 the following were discovered in the hole of an old tree:—

(*i*) A large number of adult sand-flies (*Phlebotomus* sp. near *minutus*),

(*ii*) A few *Culicoides* adults (exceedingly minute species),

(*iii*) One *Ceratopogon* adult and a fairly large number of *Ceratopogon* larvæ, and

(*iv*) Innumerable larvæ of *Culicoides* (which could be seen with difficulty with the naked eye) along with the larvæ of Syrphidæ, of *Psychoda* and of a species of acalyptrate fly.

" Young stages of the sand-fly could nowhere be found. Some *Culicoides* and *Ceratopogon* adults were bred out.

" The *Culicoides* larvæ could never be found in the loose debris within the hole but they lodged themselves in the fungi and other vegetation that had overgrown the inner walls of the hole. The position, shape and depth of the hole afforded ready protection against wind and rain, the source of blood, their food-supply, being probably a large gecko which was found inhabiting it (some of the *Phlebotomus* adults were frequently noticed gorged with blood)."

Mr. H. N. Sharma, Entomological Assistant, submits the following report on his work during the year :—

" On the Imperial Pathological Entomologist receiving orders to investigate Culicifuges for the Military Department, I was directed by him accordingly first to make an inquiry by practical tests into official or other well-known preparations and then into any other substances which might suggest themselves as possibly helpful in securing the ultimate object of the inquiry. This object was to obtain a preparation absolutely effective against mosquitos for a period of not less than three hours.

" According to the above directions the work was arranged under the following heads : —

" (*i*) Severe practical tests of preparation in official or general use; 16 preparations were tested against hungry *Armigeres obturbans*, in cages containing not less than 100 females. Three grams of solid or $2\frac{1}{2}$ ccm. of liquid preparations, covering the hand and the forearm up to an inch

below the elbow, were used in each test. The numbers represent time in minutes before biting began.

"Two lasted for an average of 1½ hours, three for one hour, the rest for less than an hour. In the case of each of the three first-named preparations (Nos. 1, 2 and 3) one mosquito bit before the expiration of 10 minutes during one test, although general biting did not begin till long afterwards and all the mosquitos were hungry. In taking the average figure, these three results have been omitted, as also one test in which Lawson's pomade remained effective for 155 minutes.

"The following is the detailed list and the figures, as given, fairly represent the relative average efficacy of the different preparations :—

(1) Lawson's Mosquito Pomade .	89	Consistency good. Irritation perceptible when fresh but transient.
(2) Cassia, camphor and soft-paraffin (official).	87	Consistency fair. Irritation very perceptible.
(3) Citronella	62	Liquid. Irritation negligible.
(4) Eucarcit	60	Liquid. Irritation negligible.
(5) Paraquit vaseline (Messrs. Thomas).	54	Liquid. Irritation negligible.
(6) Muscatol	42	Liquid. Irritation negligible.
(7) Bamber oil (official) . .	42	Liquid. Irritation negligible.
(8) Mosquito essence (A. and N. Stores).	17	Liquid. Irritation negligible.
(9) Menthol and Turpentine .	17	Liquid. Irritation negligible.
(10) Napthaline (3), soft soap (1) (official).	16	Consistency not very good. Irritation negligible.
(11) N. C. I. Powder (official) .	15	
(12) Kerosine oil	9	
(13) Eucalyptus oil (Kemp) . .	7	
(14) Keating's powder . . .	2	

(15)	Vermijelli (official) . . .	1
(16)	Carbolic acid (3), soft soap (1)	Can hardly be tested as it removes the epidermis.

"(*ii*) Similar tests were made with about 140 other substances from which it appears that it is hardly possible to produce a preparation which will remain fully effective for 3 hours.

"A brief list of some of those substances which remain effective for over 9 minutes is given below :—

(1)	Cinnamic aldehyde (13), castor oil (100) . .	100
(2)	Creosote (1), Kerosine (19)	60
(3)	Creosote (5), Castor oil (100)	50
(4)	Cresol (5), Castor oil (100)	55
(5)	Carbolic acid (5), Castor oil (100) . . .	40
(6)	Iodoform (5), Methylated spirit (100) . .	45
(7)	Thymol (5), Methylated spirit (100) . .	25
(8)	Mustard oil	25
(9)	Alcoholic extract of bed bugs	15
(10)	Proposote (creosote, phenyl propionate) . .	36
(11)	Safrol (50), Castor oil (100)	30
(12)	Vinegar	20
(13)	Napsal (10), Castor oil (100)	20
(14)	Alcoholic ext. of Butch	10
(15)	Orthonitrotoluol (10), Castor oil (100) . .	10
(16)	Tar oil (5), Castor oil (100)	10

"(*iii*) Tests of repellent power at a distance of 3-4 inches. About 40 substances were tested by a comparative method. These led to the conclusion that (1) the factors concerned with distance repulsion and contact repulsion are probably not identical; (2) neither distance repulsion nor contact repulsion is apparently proportional to the poisonous effect on the mosquito of the vapour of the substance used; (3) mosquitos probably cannot be kept at a distance from the body (by any practically applicable chemical repellent) for any length of time. The following is the list of some of the chemicals tried. They are in order of their merits in each of the three series :—

(1) (*i*) Creosote, Napthaline, (*ii*) Wood oil, (*iii*) Oil of Cassia, (*iv*) Eucalyptus oil, (*v*) Lavender oil,

(*vi*) Citronella oil, (*vii*) Kerosine oil, (*viii*) Formalin, (*ix*) Acetic acid, (*x*) Mustard oil, (*xi*) Tincture of Iodine, (*xii*) Methylated spirit.

(2) (*i*) Phenol, Citronella, Anilin, Thymol, Methylated salicylate, (*ii*) Benzine, Acetic acid, Iodoform, Cresol, Carvacrol and Amyl alcohol.

"2. Electrical X-rays experiment. Mosquito larvæ of various ages, pupæ and imagines were exposed. The effect of the one-minute exposure on the newly hatched (one hour old) larvæ was very prominent, all of them dying within 29 hours. The other stages did not seem affected. This experiment could not be repeated owing to want of facilities.

"3. Observations were made on the effects of depressants on rats. Small doses of cocaine mixed up with *bajri* flour, formed into a dough and made into small balls, were offered to *Mus rattus*. The rats were kept singly in cages. At the end of three days the rats developed peculiar symptoms; they grew wild and bit at my hand and also at cage bars and other materials when offered to them. On the eighth day they showed cannibalistic symptoms and destroyed one another.

"4. Mosquito classification work was continued."

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST.

(J. H. Walton, M.A., B.Sc.)

I. Administration.

Mr. C. M. Hutchinson, C.I.E., Imperial Agricultural Bacteriologist, was in charge of the Section till 10th April, 1920, when he proceeded on eighteen months' combined leave. Proposals for the expansion of the Section received sanction with effect from 26th October, 1919. Under this scheme I was appointed Assistant Bacteriologist from that date.

I was absent on six months' privilege leave from 27th August, 1919, and took over charge of the Section from Mr. Hutchinson on 11th April, 1920.

Mr. N. V. Joshi, B.A., M.Sc., L.Ag., First Assistant, was appointed to act as Assistant Bacteriologist from that date, and Mr. K. S. Viswanatham, B.A., as First Assistant.

II. Training.

Mr. K. Adinarayan Rao, a student from Mysore State, completed his training in agricultural bacteriology on the 5th of April, 1920.

III. Soil Biology.

Nitrification. Investigations of the nitrification of cowdung, cow urine, and sheep fold manure were carried out, and a paper on the subject was read at the Indian Science Congress, Nagpur, 1920, by Mr. Joshi. In the case of cowdung it was found that, when added in the fresh state, no nitrate accumulation took place, but when added after storing, under either aerobic or anaerobic conditions, about one-third of its nitrogen was converted into nitrate. The nitrogen of the urine was rapidly converted into nitrate in the soil. The inhibiting effect of excess of carbohydrate

on nitrification was shown by the results obtained when straw was added with the dung or urine. The losses of nitrogen that take place during storage are being further investigated.

Observations of the effect of these manures on the crop yield of oats in pot culture showed the growth of the plant to correspond to the amount of nitrate formed in the nitrification tests, but where a bad physical condition was produced in the soil, the yield was smaller than that expected from consideration of the nitrate figures.

Oats were grown in both pots and plots to which roots, stems, and leaves or the whole plant of *dhaincha* (*Sesbania aculeata*) and cowpea were added. The crops obtained corresponded to the nitrate formation obtained in the laboratory nitrification tests with these plants and their parts.

Study of the wide variations in the accumulation of nitrate during the decomposition of various oil-cakes in Pusa soil tend to the conclusion that they are due to the differences in the relative proportions of carbohydrate and nitrogen in the cakes. The oil content had very slight influence on nitrification and the addition of such materials as cellulose, filter paper, sawdust, starch, cane sugar and glucose to cakes rich in nitrogen, retarded the accumulation of nitrate. Further, in the case of *mahua* (*Bassia latifolia*) cake, no nitrate was found after eight weeks' incubation, except when the cake had previously been fermented.

The nitrogen content of soil under fallow and growing crops was studied. Both nitrate and organic nitrogen contents of the cropped plots were lower than those of fallow plots and the differences were greatest during the period of most active growth of the crop.

Biological analysis of soils. Biological analysis of soil from an abandoned coffee estate in Mysore was carried out.

Nitrogen fixation. Experiments on the effect of the accumulated products of its metabolism on the nitrogen-

fixing power of Azotobacter are being carried out. So far it appears that these products appreciably lower the amount of nitrogen fixation.

Numerous colonies of actinomycetes have invariably been found growing on Ashby's mannite agar plates, inoculated with a dilute soil suspension. Twelve species were examined for nitrogen-fixing power. Only minute gains were recorded, but as this group of organisms is one of the most abundant in soil, their accumulated effect may be of considerable importance, and further investigations of their activities are being taken up.

Seven soils, two from Pusa and five from Mysore, were examined for nitrogen fixation under anaerobic conditions. In liquid culture gains of up to 6·5 mgm. nitrogen per gram dextrose were obtained. Sugarcane megasse has proved an admirable medium for the growth of nitrogen-fixing organisms. After inoculation with mixed cultures of nitrogen-fixing organisms, its nitrogen content rose from 0·27 per cent. to 1·3 per cent. in two months.

IV. Indigo.

Owing to the short rainfall and backward condition of the plant no experiments in manufacture have been carried out since those mentioned in the last report.

Pure cultures of indican hydrolysing bacteria were maintained in the laboratory; the culture In_{10}, the most efficient, isolated three years ago, has lost none of its efficiency in that period.

V. Sterilization of water.

Investigations on this subject were continued, and supplies of the sterilizer "E.C." were manufactured for the weekly disinfection of the wells on the estate.

Two to three per cent. of available chlorine was found to be the maximum possible obtainable with economy of current consumption, and in higher concentrations stability

rapidly diminished. 2·5 per cent. is the optimum aimed at for economy in production and stability of the product.

Stability tests showed that solutions of this strength could be made stable for six weeks at plains temperatures (30° C.) and for six months or more at hill stations (20°—22° C.).

VI. Pebrine.

The work on pebrine was taken over by Dr. A. Pringle Jameson, Protozoologist, who arrived in October 1919. Laboratory accommodation is being provided for him and his staff in this Section.

VII. Programme of work for 1920-21.

1. *Major subjects.*

General biology of soil—

(*a*) Nitrogen fixation, symbiotic and asymbiotic.

(*b*) Bacterial fermentation of organic matter in soils.

(*c*) Influence of bacterial action on availability of phosphates in the soil.

2. *Special enquiries.*

(*a*) Indigo manufacture.

(*b*) Other industrial problems connected with micro-biological activities.

3. *Minor subjects.*

(*a*) Plant pathology.

(*b*) Revision of laboratory methods in soil biology.

VIII. Publications.

Hutchinson, C. M. . Report on Agricultural Bacteriology, 1918-19, for the Board of Scientific Advice.

Hutchinson, C. M. . Pebrine in India. *Mem. of the Dept. of Agri. in India*, Vol. I, No. 8. (*In the press.*)

Joshi, N. V. . . Studies in Biological Decomposition of Cow-dung and Urine in Soil. *Agri. Jour. of India*, Vol. XV, No. 4. (*In the press.*)

Joshi, N. V. . . Studies on the Root Nodule Organism of the Leguminous Plants. *Mem. of the Dept. of Agri. in India*, Vol. I, No. 9. (*In the press.*)

REPORT OF THE PROTOZOOLOGIST.

(A. Pringle Jameson, D.Sc.)

I joined my appointment at Pusa on 17th October, 1919, but considerable inconvenience and delay were experienced in getting the work on silk-worm diseases properly started on account of the extreme slowness with which the apparatus ordered at home was delivered—although ready for dispatch in September 1919, the last consignment was not received until April 1920—and also on account of the lack of assistants, sanction for staff not having been received until May. If it had not been for the kindness of Mr. C. M. Hutchinson and other heads of Sections who lent me sufficient assistance and apparatus to go on with, it would have been practically impossible to have started certain lines of work.

The first silk-worm disease that is being investigated is pebrine. This disease is caused by a very minute protozoan parasite. Sixty years ago the silk industry in Europe was nearly extinguished by it and fears are entertained lest it should assume equally serious proportions in India. The work on this disease was initiated by Mr. Hutchinson and it is being carried on from the point where he left off. It falls naturally into two parts. First the investigation of the life-history of the parasite, *Nosema bombycis*, which causes the disease, and second the investigation of means of controlling the disease. The second line of inquiry is, of course, more or less dependent on the results of the first.

(*a*) *Life-history of the parasite.* Attention is being paid at present to the early stages of the life-history—the behaviour of the spores when introduced into the gut of the silk-worm and the initial attacks of the parasite on the tissues of the host. This work is very difficult to carry on in the hot weather as much of it entails the cutting of extremely thin paraffin wax sections, but already a considerable amount of information has resulted from this line of investigation. It is, however, much too early in the in-

quiry to make any definite pronouncements on the life-history.

(*b*) *Experiments on disease control.* The following are some of the lines of investigation being pursued. Various races of silk-worms are being tested regarding their resistance to disease. Three small *kutcha* rearing houses have been erected and in them experiments on disinfection, length of life of spores, and methods of infection are being conducted. The effect of climatic conditions on disease is being tested. Various rearing methods are being investigated in relation to disease. Certain extremely interesting facts have been brought to light by these experiments, especially with regard to infection of the worms in surroundings highly charged with infectious material and also with regard to the lethal qualities of the disease. But here again the time has not yet come for making any definite statements.

The Government of India having accepted Professor Lefroy's recommendation that a seed supply station be established in Shillong, the matter is now being pushed on. A site for the laboratory buildings has been given by the Governors of the Pasteur Institute and a plot of land for growing mulberry has been selected. The plans and estimates have been drawn up and final sanction is awaited. It is hoped that building operations will be started immediately and the main buildings erected by October. Several hundred mulberry cuttings have been set out in the Shillong Fruit Farm by the Superintendent, Mr. C. H. Holder, to whom thanks are due for his kind assistance.

Programme of work for 1920-21.

The investigation of the life-history of *Nosema bombycis* is being continued. The experiments on disease control, etc., will be carried on and expanded in the light of the results obtained. Experiments on a large scale to test the value of hill amelioration will be started next year, as soon as a station is established in the hills. It is hoped that a beginning will be made with the study of flacherie.

APPENDIX.

REPORT OF THE SECRETARY, SUGAR BUREAU.

(WYNNE SAYER B.A.)

I was placed on special duty for a period of two years with effect from 20th January, 1919, to undertake the collection of all available information in connection with the sugar industry in India, pending a further consideration by the Government of India of the question of establishing a Sugar Bureau. An establishment of two recorders, two clerks, and two typists, with one Superintendent, was sanctioned to enable me to carry on the work, but one of these posts has been vacant for the whole time, the pay and the temporary position not being sufficient to attract a suitable man. The designation of my post was changed to that of the Secretary, Sugar Bureau, with effect from 13th April, 1919.

It will not be out of place here to give a brief history of the successive steps Government have taken to encourage the industry, in the course of which this office came to be created.

Scientific work on the sugarcane crop was started at Manjri in the Bombay Presidency by Mr. Mollison in 1894 and at Samalkot in Madras by Dr. Barber towards the close of the last century. In these two Presidencies some valuable results were obtained. In Bengal and the United Provinces also some work had been done. But it was after the Agricultural Departments were re-organized by Lord Curzon's Government in 1905 that the foundations of the important work being done by Mr. G. Clarke at Shahjahanpur, Mr. Somers Taylor and the late Mr. Woodhouse at Sabour, Mr. Meggitt in Assam, Mr. Clouston in the Central Provinces, and Mr. Robertson Brown at Peshawar in the North-West Frontier Province were laid, while the work already in progress in Madras and Bombay was expanded.

In 1911 Pandit Madan Mohan Malaviya moved a resolution in the Imperial Legislative Council recommending that the duty on imported sugar should be so raised as to make it possible for the indigenous sugar industry to survive the competition to which it was exposed. The late Mr. Gokhale moved an amendment recommending that Government should order an enquiry by a Committee of competent persons into the present condition of the sugar industry in India with a view to ascertaining what action could and should be taken by the State to save the industry from the threatened ruin. He pointed out that there was a great deal that Government could do for the industry even if it did not impose a high protective tariff, in the matter, for instance, of

making the services of expert chemists available, in the matter of the terms on which land might be held, in the matter of irrigation and other facilities and so forth. Government replied that they were alive to the position and were doing their best to improve the methods of cane cultivation and the manufacture of sugar throughout the country. Both the resolution and the amendment were lost. But in November of the same year the question of the Indian sugar industry was considered by the Board of Agriculture in India, and as the result of its recommendations the appointments of a Sugarcane Expert and a Sugar Engineer were sanctioned for a term of years. The headquarters of the former officer were located at Coimbatore in Southern India as canes were found to flower there (this is not the case in Northern India), facilitating thereby the work of raising better varieties of canes by crossing. The Sugar Engineer was stationed in the United Provinces where more than half the total acreage under the crop is grown, his duties being to work out the smallest economical size of a sugar factory suitable for Indian conditions and to advise the public on factory matters. As stated above, both these were on a temporary footing. Nevertheless they marked a stage forward in the policy of developing the Indian sugarcane industry. Since then almost every meeting of the Board has reviewed the work done on this crop at the various experiment stations in the country.

The great European war brought the question of the Empire sugar supply to the forefront. The usual sources of beet sugar supply, Germany, Austria-Hungary and Russia, having been cut off, the world was faced with a serious shortage of sugar, and India in common with the rest had to pay heavily for her imports. It was in these circumstances that the Board of Agriculture met at Poona in December 1917, and the opinion was unanimous that the time was ripe for making a further move in the policy of developing the Indian sugarcane industry. It was the general opinion of the Board that no time should be lost in starting an office where information on all aspects of the Indian sugar industry could be obtained, the information available at that time being scattered in the Secretariats of the various Governments in India, in the records of the late Reporter on Economic Products to the Government of India, and in the offices of the Director-General of Commercial Intelligence, the Government Sugarcane Expert, and the Directors and Deputy Directors of Agriculture in the provinces; this information was to be collected, sifted, reviewed and made available to Government and the public. In view of the prevailing high price of sugar acting as an incentive to putting up factories

in the country it was most desirable that there should be a central organization where reliable information, advice, and assistance could be had.

It will thus be seen that the formation of this office was a natural evolution of the series of steps which the Government had already taken for the improvement of the Indian sugarcane industry. The appointment of the Indian Sugar Committee during the year by the Government of India with the Secretary of State's approval marks a further step in the same direction. It is expected that the Committee will submit definite recommendations as to the Sugar Bureau's constitution and functions, its relation to the provinces, and where it should be located.

The first piece of work undertaken by me was the collection and indexing of all available literature on the subject published in India, sifting the masses of information available in various offices and arranging them in a form convenient for reference. Much progress has been made in this direction, but it was impossible to pay undivided attention to this part of the work as numerous correspondents began to seek advice as soon as the office was established and I was in charge of the duties of the post of Imperial Agriculturist up to 4th January, 1920, and was also appointed a member of the Indian Sugar Committee. Enquiries relating to sugar and sugarcane began also to be transferred to this office by the Agricultural Adviser to the Government of India, the Government Sugarcane Expert, Director-General of Commercial Intelligence, and other officers. The enquiries range from mere requests for statistical information regarding acreage, yield of sugarcane per acre and imports of sugar in India, to varieties of cane, methods of cultivation, manures required, localities where sugar factories can be put up, the machinery required and how to get it, etc.

As it is most essential to have an up-to-date library for a central place of reference like this, steps have been taken to lay the foundations of one which will grow in future. During the year under review 1,448 volumes have been received either by purchase, exchange, or free supply, and they are being continually added to. Scientific and other periodicals bearing on this industry are being subscribed for.

During the year under report I placed myself in touch with almost all the sugar experiment stations of the world, the principal sugar machinery manufacturers in Great Britain and the United States of America. In India I am in touch with all the sugar factories and also with the officers of the provincial Departments of Agriculture connected with sugar and sugarcane.

As mentioned above, I have been appointed a member of the Indian Sugar Committee in addition to my duties as Secretary, Sugar Bureau, with effect from 26th October, 1919. This has given me a further opportunity of getting first hand knowledge of the existing state of the Indian sugar industry.

On 14th May, 1920, I and the Superintendent of my office, Rao Sahib Kasanji D. Naik, proceeded with the Sugar Committee to Java. Here the opportunity was taken of inspecting all the libraries in the experiment stations and in the office of the Secretary to the Java Sugar Syndicate. A great deal of literature was collected, and numerous points on which we were uncertain as to the methods adopted in Java were cleared up. I also brought back with me a collection of the latest Java varieties, including a cane specially recommended for North India by Dr. Jesweit, Sugarcane-breeding Expert, Pasoeroean Experiment Station, which have been sent on to the Coimbatore Cane-breeding Station for planting. I have also arranged by the kindness of Dr. Jesweit, and Dr. Kuyper, officiating Director of the Pasoeroean Experiment Station, to get any crosses done of canes which do not flower in India. It is anticipated that this will be of invaluable assistance to the sugar industry in Bihar, as no crossing has hitherto been possible with the Mungo family which up to date has refused to flower in India.

Publication.

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